

DOC.
Y 3.N88:
25/5250/v.3

NUREG/CR-5250
UCID-21517
Vol. 3

Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains

Results and Discussion for the Batch 2 Sites

Prepared by D. L. Bernreuter, J. B. Savy, R. W. Mensing, J. C. Chen

Lawrence Livermore National Laboratory

Prepared for
U.S. Nuclear Regulatory
Commission

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability of responsibility for any third party's use, or the results of such use, of any information, apparatus, product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights.

UNIVERSITY OF
ILLINOIS LIBRARY
AT URBANA-CHAMPAIGN
BOOKSTACKS

NOTICE

Availability of Reference Materials Cited in NRC Publications

Most documents cited in NRC publications will be available from one of the following sources:

1. The NRC Public Document Room, 1717 H Street, N.W.
Washington, DC 20555
2. The Superintendent of Documents, U.S. Government Printing Office, Post Office Box 37082,
Washington, DC 20013-7082
3. The National Technical Information Service, Springfield, VA 22161

Although the listing that follows represents the majority of documents cited in NRC publications, it is not intended to be exhaustive.

Referenced documents available for inspection and copying for a fee from the NRC Public Document Room include NRC correspondence and internal NRC memoranda; NRC Office of Inspection and Enforcement bulletins, circulars, information notices, inspection and investigation notices; Licensee Event Reports; vendor reports and correspondence; Commission papers; and applicant and licensee documents and correspondence.

The following documents in the NUREG series are available for purchase from the GPO Sales Program: formal NRC staff and contractor reports, NRC-sponsored conference proceedings, and NRC booklets and brochures. Also available are Regulatory Guides, NRC regulations in the *Code of Federal Regulations*, and *Nuclear Regulatory Commission Issuances*.

Documents available from the National Technical Information Service include NUREG series reports and technical reports prepared by other federal agencies and reports prepared by the Atomic Energy Commission, forerunner agency to the Nuclear Regulatory Commission.

Documents available from public and special technical libraries include all open literature items, such as books, journal and periodical articles, and transactions. *Federal Register* notices, federal and state legislation, and congressional reports can usually be obtained from these libraries.

Documents such as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings are available for purchase from the organization sponsoring the publication cited.

Single copies of NRC draft reports are available free, to the extent of supply, upon written request to the Division of Information Support Services, Distribution Section, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at the NRC Library, 7920 Norfolk Avenue, Bethesda, Maryland, and are available there for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

NUREG/CR-5250
UCID-21517
Vol. 3

Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains

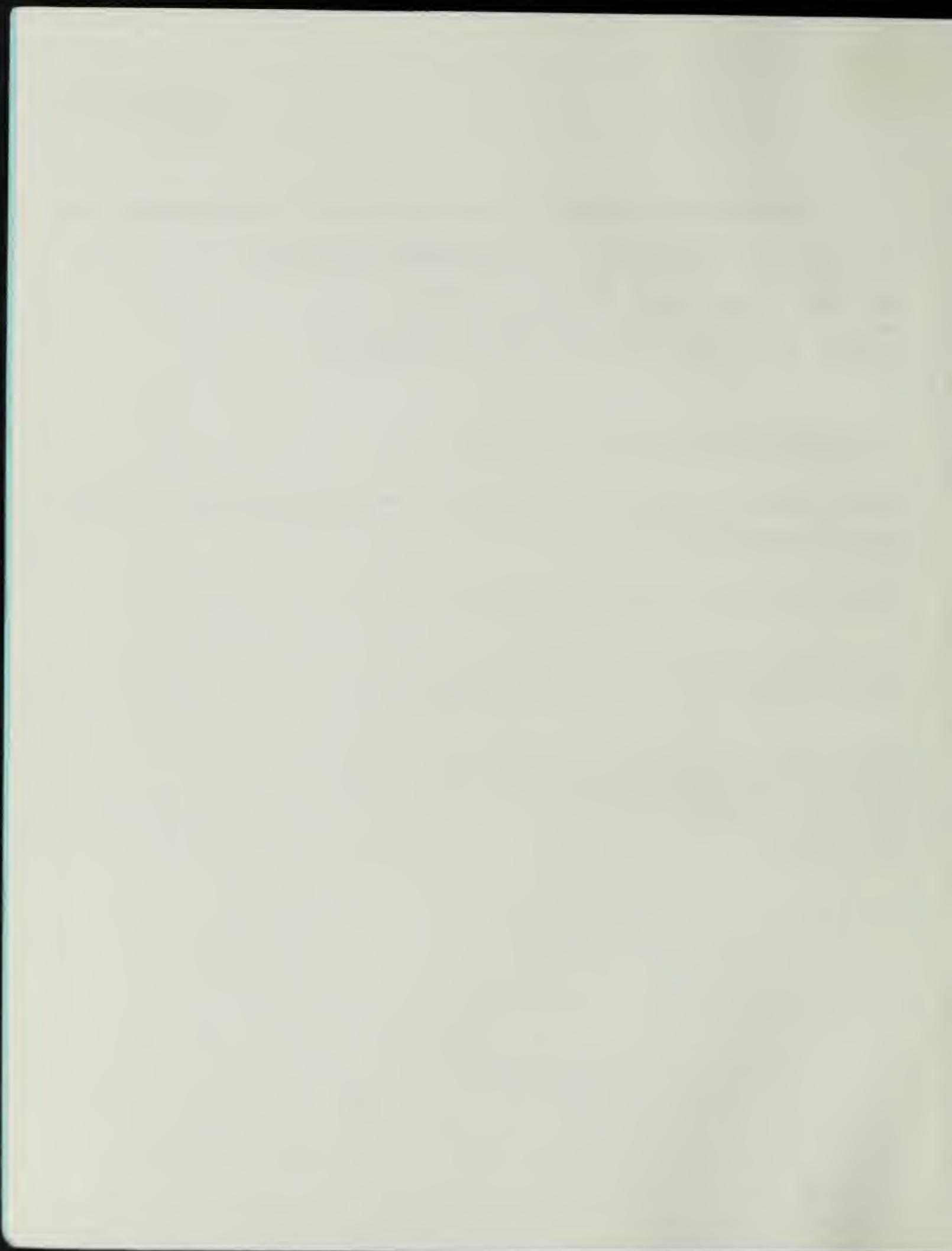
Results and Discussion for the Batch 2 Sites

Manuscript Completed: November 1988
Date Published: January 1989

Prepared by
D. L. Bernreuter, J. B. Savy, R. W. Mensing, J. C. Chen

Lawrence Livermore National Laboratory
7000 East Avenue
Livermore, CA 94550

Prepared for
Division of Engineering and System Technology
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555
NRC FIN A0448



DOC.
Y3. N88:
AS/5250/V.3

Abstract

The EUS Seismic Hazard Characterization Project (SHC) is the outgrowth of an earlier study performed as part of the U.S. Nuclear Regulatory Commission's (NRC) Systematic Evaluation Program (SEP). The objectives of the SHC were: (1) to develop a seismic hazard characterization methodology for the region east of the Rocky Mountains (EUS), and (2) the application of the methodology to 69 site locations, some of them with several local soil conditions. The method developed uses expert opinions to obtain the input to the analyses. An important aspect of the elicitation of the expert opinion process was the holding of two feedback meetings with all the experts in order to finalize the methodology and the input data bases. The hazard estimates are reported in terms of peak ground acceleration (PGA) and 5% damping velocity response spectra (PSV).

A total of eight volumes make up this report which contains a thorough description of the methodology, the expert opinion's elicitation process, the input data base as well as a discussion, comparison and summary volume (Volume VI).

Consistent with previous analyses, this study finds that there are large uncertainties associated with the estimates of seismic hazard in the EUS, and it identifies the ground motion modeling as the prime contributor to those uncertainties.

The data bases and software are made available to the NRC and to public uses through the National Energy Software Center (Argonne, Illinois).

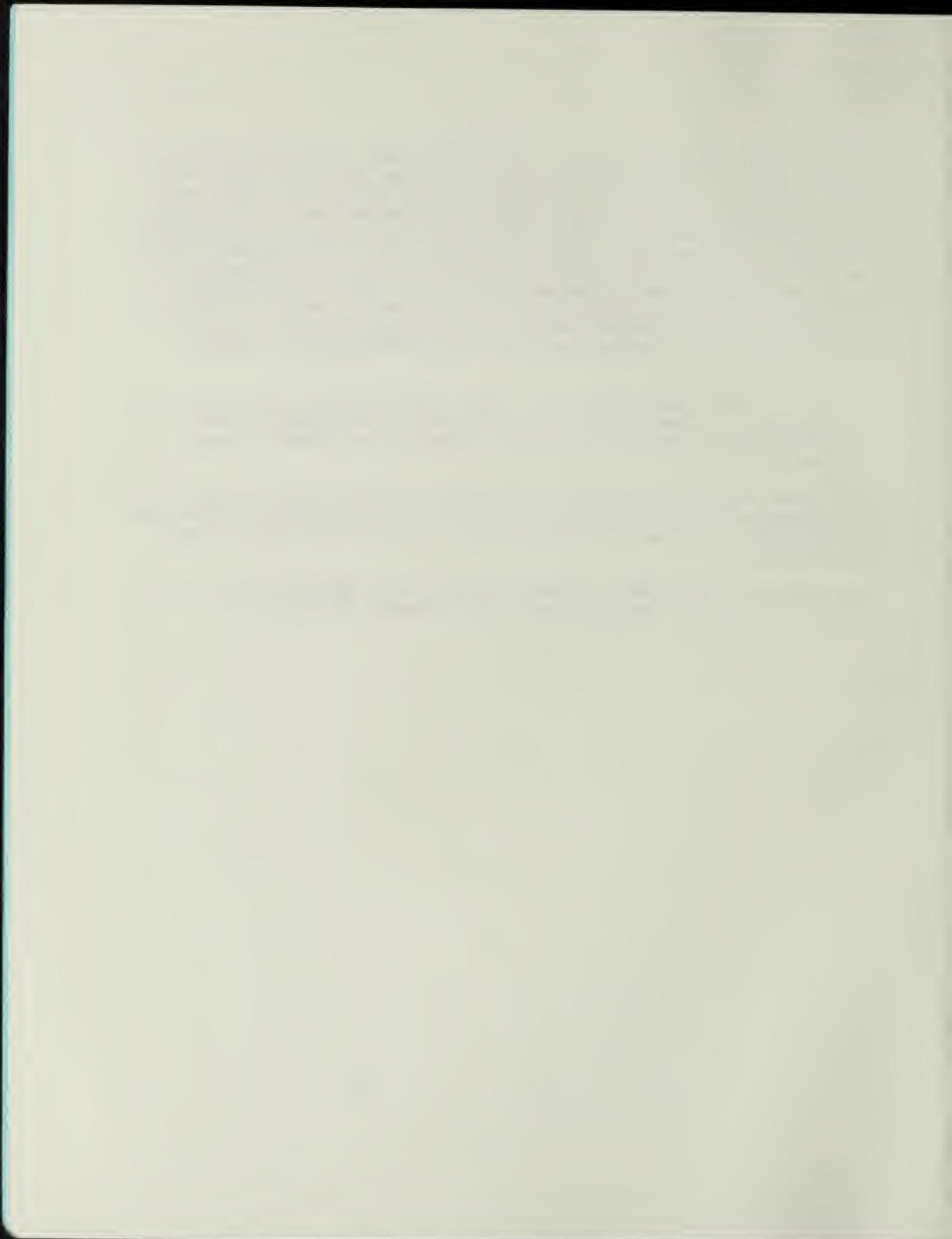
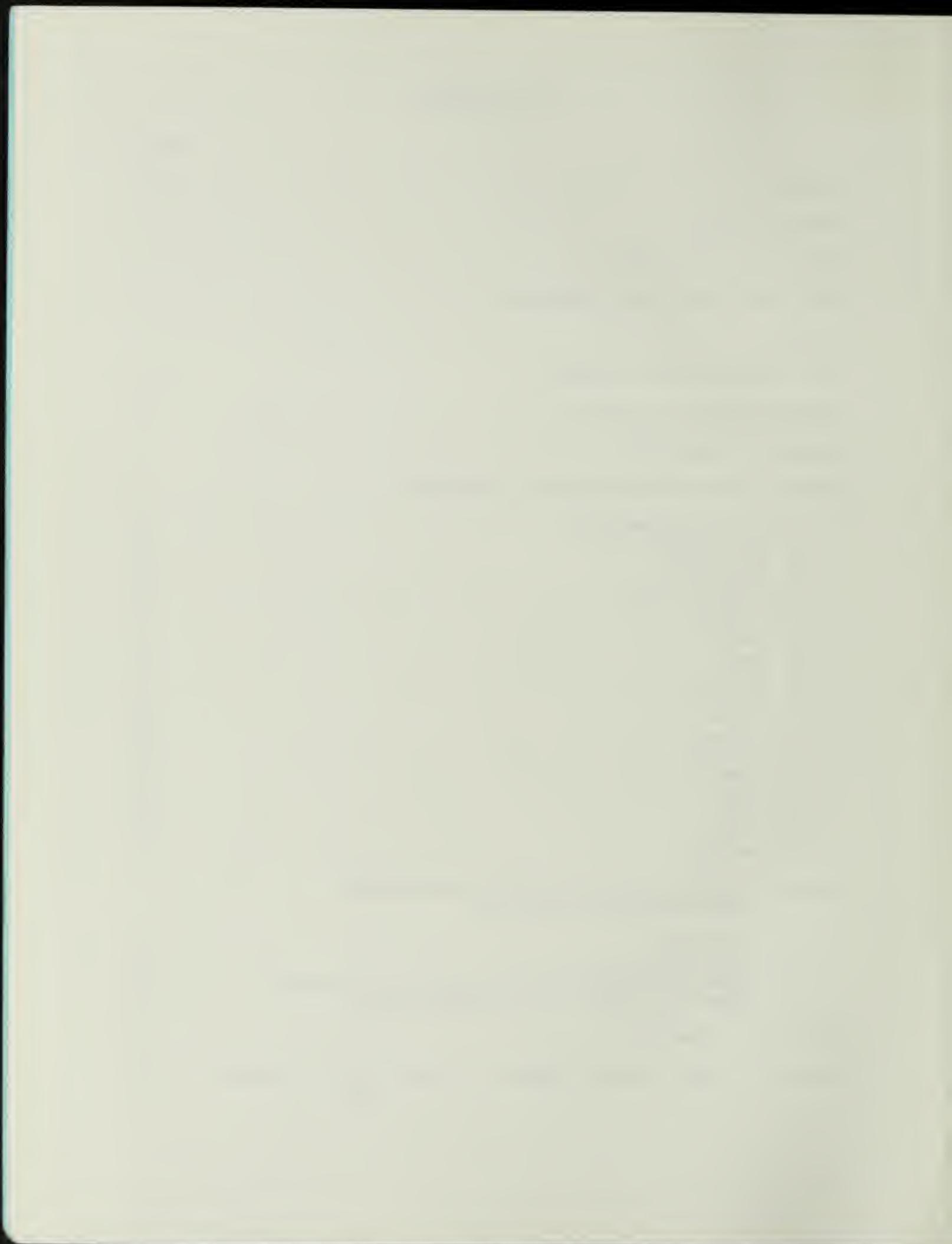


Table of Contents
Volume III

	<u>PAGE</u>
Abstract	iii
Table of Contents	v
List of Tables and Figures	vii
List of Additional Tables and Figures	ix
Foreword	xiii
List of Abbreviations and Symbols	xviii
Executive Summary: Volume III	xxi
SECTION 1 INTRODUCTION	1
SECTION 2 RESULTS AND SITE SPECIFIC DISCUSSION	8
2.0 General Introduction	8
2.1 Bellefonte	12
2.2 Browns Ferry	28
2.3 Brunswick	40
2.4 Calvert Cliffs	52
2.5 Catawba	65
2.6 Farley	77
2.7 Hatch	89
2.8 McGuire	101
2.9 North Anna	113
2.10 Oconee	125
2.11 Robinson	138
2.12 Sequoyah	150
2.13 Shearon Harris	162
2.14 Summer	174
2.15 Surry	186
2.16 Vogtle	199
2.17 Watts Bar	211
SECTION 3 GENERAL DISCUSSION, REGIONAL OBSERVATIONS, AND COMPARISONS BETWEEN SITES	223
3.1 Uncertainty	223
3.2 Sensitivity to region choice	224
3.3 Factors influencing zonal contribution to the hazard	224
3.4 Comparison of seismic hazard between sites	227
APPENDIX A References	A-1
APPENDIX B Maps of Seismic Zonations for Each of the 11 S-Experts	B-1



List of Tables and Figures

The same format for the tables and figures are used for every site. The following is an exhaustive list of all tables and figures presented in this volume.

The symbol "SN" in the following refers to "Site Number" and the corresponding page numbers are given in the table on page xi.

- (1) Table 1.1 Sites and Soil Category Used for Each Site in Batch 2
- (2) Table 1.2 Final EUS Zonation and Seismicity Panel Members (S-Panel)
- (3) Table 1.3 Final EUS Ground Motion Modeling Panel Members (G-Panel)
- (4) Table 1.4 Definition of the Eight Site Categories

- (1) Figure 2.SN.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the SN site.
- (2) Figure 2.SN.2 BEHCs per S-Expert combined over all G-Experts for the SN. Plot symbols given in Table 2.0.
- (3) Figure 2.SN.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the SN site.
- (4) Figure 2.SN.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the SN site.
- (5) Figure 2.SN.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the SN site.
- (6) Figure 2.SN.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the SN site. Plot symbols are given in Table 2.0.

- (7) Figure 2.SN.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the SN site.
- (8) Figure 2.SN.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the SN site.
- (9) Figure 2.SN.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the SN site.
- (10) Figure 2.SN.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the SN site.
- (11) Figure 2.SN.11 Comparison of the BEHC for PGA per G-Expert for S-Expert 1's input for the SN site.
- (12) Figure 2.SN.12 Comparison of the BEHC for PGA per G-Expert, for a given S-Expert's input for the SN site.

List of Additional Tables and Figures

	<u>PAGE</u>	
Table 2.0	Plot symbol key used for individual S-Experts on Figs. 2.SN.2 and 2.SN.6	11
Figure 1.1	Map showing the location of the Batch 2 sites contained in Vol. III of this report. Map symbols are given in Table 1.1.	7
Figure 3.1.1	Comparison of the 15th, 50th and 85th percentile CPHCs for PGA between the Hope Creek and Salem sites. Repeated from Vol. II.	230
Figure 3.1.2	Comparison of the 15th, 50th and 85th percentile CPHCs for PGA between two different Monte Carlo runs for the Fitzpatrick site. Repeated from Vol. II.	231
Figure 3.2.1	Comparison of the BEHCs and AMHCs between the case when the Hope Creek site is considered to be located in region 1 and the case when it is considered to be located in region 2.	232
Figure 3.2.2	Comparison of the 10,000 year return period 15th, 50th and 85th percentile CPUHS for the Hope Creek site between the case when the Hope Creek site is considered to be located in region 1 and the case when it is considered to be located in region 2.	233
Figure 3.2.3	Comparison of the BEHCs and AMHCs for the Limerick site between the case when the Limerick site is considered to be located in region 1 and the case when it is considered to be located in region 2.	234
Figure 3.2.4	Comparison of the 10,000 year return period 15th, 50th and 85th percentile CPUHS for the Limerick site between the case when the Limerick site is considered to be located in region 1 and the case when it is considered to be located in region 2.	235

	<u>PAGE</u>	
Figure 3.3.1a	BEHCS which include only the contribution to the PGA hazard from earthquakes within the indicated distance ranges for a site in the EUS when the lower bound of integration for magnitude is 5.0.	236
Figure 3.3.1b	BEHCS which include only the contribution to the PGA hazard from earthquakes within the indicated distance ranges for the site considered in Fig. 3.3.1a when the lower bound of integration is 3.75.	237
Figure 3.3.2a	BEHCS which include only the contribution to the PGA hazard from earthquakes within the indicated distance ranges for a rock site of the EUS.	238
Figure 3.3.2b	Same as Fig. 3.3.2a except only G-Experts 1-4 BE GM models were used.	239
Figure 3.3.3a	BEHCS for a rock site located in the northern part of region 1 which include only the contribution to the hazard for PGA from earthquakes within the indicated distance ranges.	240
Figure 3.3.3b	BEHCS for a soil site located in the northern part of region 1 which include only the contribution to the PGA hazard from the earthquakes within the indicated distance ranges.	241
Figure 3.4.1	Comparison of the median CPHCs for PGA between the Vermont Yankee and Yankee Rowe site.	242
Figure 3.4.2	Comparison of the median CPHCs for PGA for 5 sites of region 2.	243
Figure 3.4.3	Contribution to the hazard from earthquakes segregated into four distance ranges, for the North Anna rock site, in terms of probability of exceedance of the PGA.	244
Figure 3.4.4	Contribution to the hazard from earthquakes segregated into four distance ranges, for the Shearon Harris rock site, in terms of probability of exceedance of the PGA.	245

	<u>PAGE</u>
Figure 3.4.5	Contribution to the hazard from earthquakes segregated into four distance ranges, for the Watts Bar rock site, in terms of probability of exceedance of the PGA. 246
Figure 3.4.6	Comparison of the median CPHCs of five deep soil sites in region 2, in terms of probability of exceedance of the PGA. 247
Figure 3.4.7	10,000 year, 5 percent damping median CPUHS for two sites of region 2. At North Anna the hazard is dominated by small earthquakes and at Oconee, the hazard is dominated by large earthquakes. 248
Figure 3.4.8	10,000 year, 5 percent damping median CPUHS for four plant sites in a part of region 2 dominated by the New Madrid area. 249
Figure 3.4.9	Median CPHCs for all the sites in Batch 2. The plot symbols for the sites are the same as given in Table 1.1. 250
Figure 3.4.10	Median (M) probability of exceedance of 0.2g, arithmetic mean (A), best estimate (B), 15th and 85th percentiles (*) for the 17 sites of Batch 2. 251

PAGE REFERENCE OF TABLES AND FIGURES

Site SN	Table Number	Figure Number									
		2.SN.1	2.SN.2	2.SN.3	2.SN.4	2.SN.5	2.SN.6	2.SN.7	2.SN.8	2.SN.9	2.SN.10
1. Bellefonte	15	16	17	18	19	20	21	22	23	24	25
2. Browns Ferry	29	30	31	32	33	34	35	36	37	38	39
3. Brunswick	41	42	43	44	45	46	47	48	49	50	51
4. Calvert Cliffs	53	54	55	56	57	58	59	60	61	62	63
5. Catawba	66	67	68	69	70	71	72	73	74	75	76
6. Farley	78	79	80	81	82	83	84	85	86	87	88
x. 7. Hatch	90	91	92	93	94	95	96	97	98	99	100
8. McGuire	102	103	104	105	106	107	108	109	110	111	112
9. North Anna	114	115	116	117	118	119	120	121	122	123	124
10. Oconee	126	127	128	129	130	131	132	133	134	135	136
11. Robinson	139	140	141	142	143	144	145	146	147	148	149
12. Sequoyah	151	152	153	154	155	156	157	158	159	160	161
13. Shearon Harris	163	164	165	166	167	168	169	170	171	172	173
14. Summer	175	176	177	178	179	180	181	182	183	184	185
15. Surry	187	188	189	190	191	192	193	194	195	196	197
16. Vogtle	200	201	202	203	204	205	206	207	208	209	210
17. Watts Bar	212	213	214	215	216	217	218	219	220	221	222

Foreword

The impetus for this study came from two unrelated needs of the Nuclear Regulatory Commission (NRC). One stimulus arose from the NRC funded "Seismic Safety Margins Research Programs" (SSMRP). The SSMRP's task of simplified methods needed to have available data and analysis software necessary to compute the seismic hazard at any site located east of the Rocky Mountains which we refer to as the Eastern United States (EUS) in a form suitable for use in probabilistic risk assessment (PRA). The second stimulus was the result of the NRC's discussions with the U.S. Geological Survey (USGS) regarding the USGS's proposed clarification of their past position with respect to the 1886 Charleston earthquake. The USGS clarification was finally issued on November 18, 1982, in a letter to the NRC, which states that:

"Because the geologic and tectonic features of the Charleston region are similar to those in other regions of the eastern seaboard, we conclude that although there is no recent or historical evidence that other regions have experienced strong earthquakes, the historical record is not, of itself, sufficient ground for ruling out the occurrence in these other regions of strong seismic ground motions similar to those experienced near Charleston in 1886. Although the probability of strong ground motion due to an earthquake in any given year at a particular location in the eastern seaboard may be very low, deterministic and probabilistic evaluations of the seismic hazard should be made for individual sites in the eastern seaboard to establish the seismic engineering parameters for critical facilities."

Anticipation of this letter led the Office of Nuclear Reactor Regulation to jointly fund a project with the Office of Nuclear Regulatory Research. The results were presented in Bernreuter et. al., (1985), and the objectives were:

1. to develop a seismic hazard characterization methodology for the entire region of the United States east of the Rocky Mountains.
2. to apply the methodology to selected sites to assist the NRC staff in their assessment of the implications in the clarification of the USGS position on the Charleston earthquake, and the implications of the occurrence of the recent earthquakes such as that which occurred in New Brunswick, Canada, in 1982.

The methodology used in that 1985 study evolved from two earlier studies that the Lawrence Livermore National Laboratory (LLNL) performed for the NRC. One study, Bernreuter and Minichino (1983), was part of the NRC's Systematic Evaluation Program (SEP) and is simply referred hereafter to as the SEP study. The other study was part of the SSMRP.

At the time (1980-1985), an improved hazard analysis methodology and EUS seismicity and ground motion data set were required for several reasons:

- o Although the entire EUS was considered at the time of the SEP study, attention was focused on the areas around the SEP sites--mainly in the Central United States (CUS) and New England. The zonation of other areas was not performed with the same level of detail.
- o The peer review process, both by our Peer Review Panel and other reviewers, identified some areas of possible improvements in the SEP methodology.
- o Since the SEP zonations were provided by our EUS Seismicity Panel in early 1979, a number of important studies had been completed and several significant EUS earthquakes had occurred which could impact the Panel members' understanding of the seismotectonics of the EUS.
- o Our understanding of the EUS ground motion had improved since the time the SEP study was performed.

By the time our methodology was firmed up, the expert opinions collected and the calculations performed (i.e. by 1985), the Electric Power Research Institute (EPRI) had embarked on a parallel study.

We performed a comparative study, Bernreuter et. al., (1987), to help in understanding the reasons for differences in results between the LLNL and the EPRI studies. The three main differences were found to be: (1) the minimum magnitude value of the earthquakes contributing to the hazard in the EUS, (2) the ground motion attenuation models, and (3) the fact that LLNL accounted for local site characteristics and EPRI did not. Several years passed between the 1985 study and the application of the methodology to all the sites in the EUS. In recognition of the fact that during that time a considerable amount of research in seismotectonics and in the field of strong ground motion prediction, in particular with the development of the so called random vibration or stochastic approach, NRC decided to follow our recommendations and have a final round of feedback with all our experts prior to finalizing the input to the analysis.

In addition, we critically reviewed our methodology which lead to minor improvements and we also provided an extensive account of documentation on the ways the experts interpreted our questionnaires and how they developed their answers. Some of the improvements were necessitated by the recognition of the fact that the results of our study will be used, together with results from other studies such as the EPRI study or the USGS study, to evaluate the relative hazard between the different plant sites in the EUS.

This report includes eight volumes:

Volume I provides an overview of the methodology we developed for this project. It also documents the final makeup of both our Seismicity and Ground Motion Panels, and documents the final input from the members of both panels used in the analysis. Comparisons are made between the new results and previous results.

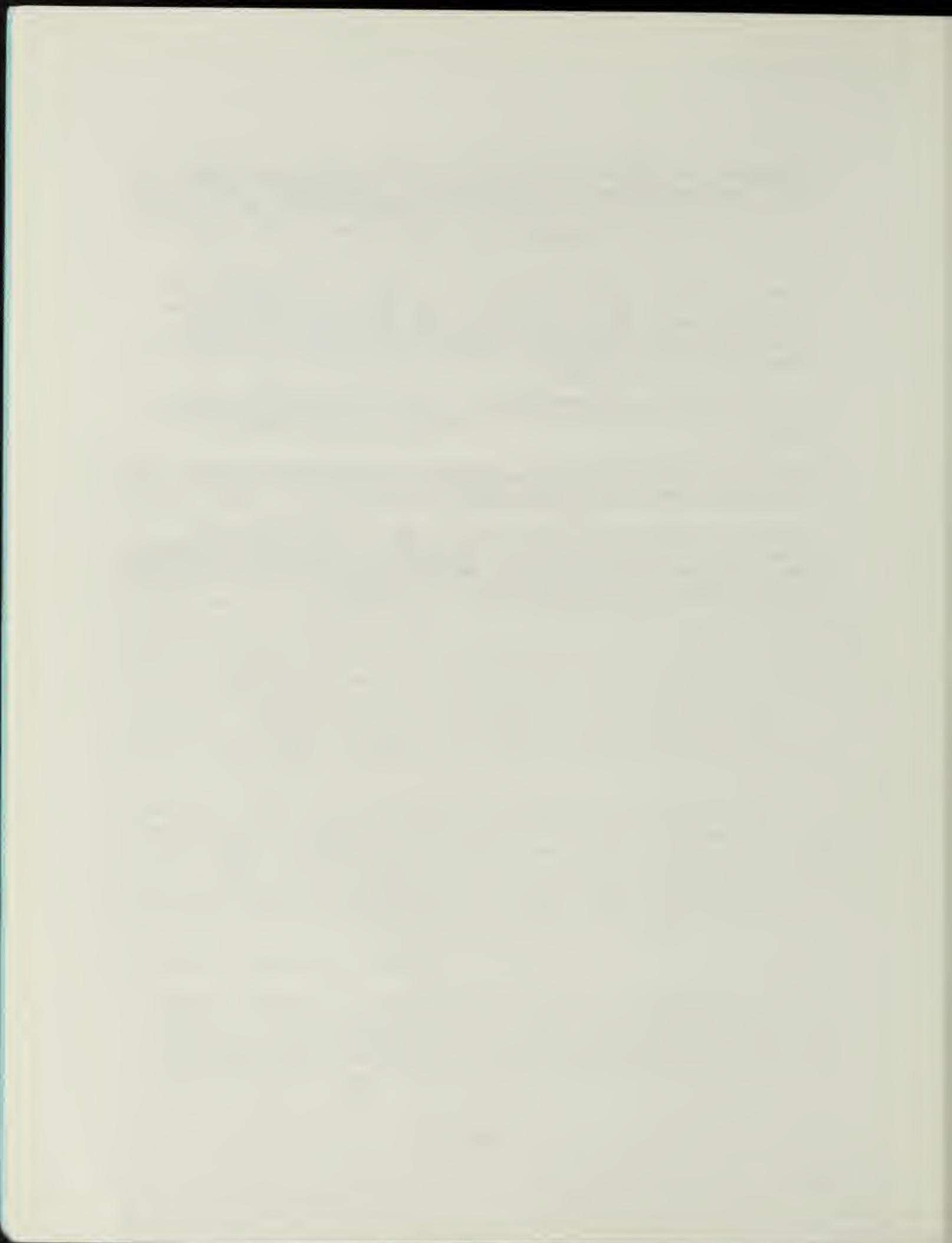
Volumes II to V provide the results for all the active nuclear power plant sites of the EUS divided into four batches of approximately equal size and of sites roughly located in the four main geographical regions of the EUS (NE, SE, NC and SC). A regional discussion is given in each of Vols. II to V.

Volume VI emphasizes important sensitivity studies, in particular the sensitivity of the results to correction for local site conditions and G-Expert 5's ground motion model. It also contains a summary of the results and provides comparisons between the sites within a common region and for sites between regions.

Volume VII contains unaltered copies of the ten questionnaires used from the beginning of the 1985 study to develop the complete input for this analysis.

After the bulk of the work was completed and draft reports for Vols. I-VII were written, additional funding became available.

Volume VIII contains the hazard result for the 12 sites which were primarily rock sites but which also had some structures founded on shallow soil. These results supplement the results given in Vols. II to V where only the primary soil condition at the site was used.



List of Abbreviations and Symbols

A	Symbol for Seismicity Expert 10 in the figures displaying the results for the S-Experts
ALEAS	Computer code to compute the BE Hazard and the CP Hazard for each seismicity expert
AM	Arithmetic mean
AMHC	Arithmetic mean hazard curve
B	Symbol for Seismicity Expert 11 in the figures displaying the results for the S-Experts
BE	Best estimate
BEHC	Best estimate hazard curve
BEUHS	Best estimate uniform hazard spectrum
BEM	Best estimate map
C	Symbol for Seismicity Expert 12 in the figures displaying the results for the S-Experts
COMAP	Computer code to generate the set of all alternative maps and the discrete probability density of maps
COMB	Computer code to combine BE hazard and CP hazard over all seismicity experts
CP	Constant percentile
CPHC	Constant percentile hazard curve
CPUHS	Constant percentile uniform hazard spectrum
CUS	Central United States, roughly the area bounded in the west by the Rocky Mountains and on the east by the Appalachian Mountains, excluding both mountain systems themselves
CZ	Complementary zone
D	Symbol for Seismicity Expert 13 in the figures displaying the results for the S-Experts
EPRI	Electric Power Research Institute

EUS	Used to denote the general geographical region east of the Rocky Mountains, including the specific region of the Central United States (CUS)
g	Measure of acceleration: $1g = 9.81 \text{m/s/s} = \text{acceleration of gravity}$
G-Expert	One of the five experts elicited to select the ground motion models used in the analysis
GM	Ground motion
HC	Hazard curve
I_o	Epicentral intensity of an earthquake relative to the MMI scale
I_s	Site intensity of an earthquake relative to the MMI scale
LB	Lower bound
LLNL	Lawrence Livermore National Laboratory
M	Used generically for any of the many magnitude scales but generally m_b , $m_b(Lg)$, or M_L .
M_L	Local magnitude (Richter magnitude scale)
M_b	True body wave magnitude scale, assumed to be equivalent to $m_b(Lg)$ (see Chung and Bernreuter, 1981)
$m_b(Lg)$	Nuttli's magnitude scale for the Central United States based on the Lg surface waves
M_S	Surface wave magnitude
MMI	Modified Mercalli Intensity
M_o	Lower magnitude of integration. Earthquakes with magnitude lower than M_o are not considered to be contributing to the seismic hazard
NC	North Central; Region 3
NE	North East; Region 1
NRC	Nuclear Regulatory Commission
PGA	Peak ground acceleration
PGV	Peak ground velocity

PRD	Computer code to compute the probability distribution of epicentral distances to the site
PSRV	Pseudo relative velocity spectrum. Also see definition of spectra below
Q	Seismic quality factor, which is inversely proportional to the inelastic damping factor.
Q1	Questionnaire 1 - Zonation (I)
Q2	Questionnaire 2 - Seismicity (I)
Q3	Questionnaire 3 - Regional Self Weights (I)
Q4	Questionnaire 4 - Ground Motion Models (I)
Q5	Questionnaire 5 - Feedback on seismicity and zonation (II)
Q6	Questionnaire 6 - Feedback on ground motion models (II)
Q7	Questionnaire 7 - Feedback on zonation (III)
Q8	Questionnaire 8 - Seismicity input documentation
Q9	Questionnaire 9 - Feedback on seismicity (III)
Q10	Questionnaire 10 - Feedback on ground motion models (III)
R	Distance metric, generally either the epicentral distance from a recording site to the earthquake or the closest distance between the recording site and the ruptured fault for a particular earthquake.
Region 1 (NE):	North East of the United States, includes New England and Eastern Canada
Region 2 (SE):	South East United States
Region 3 (NC):	North Central United States, includes the Northern Central portions of the United States and Central Canada
Region 4 (SC):	Central United States, the Southern Central portions of the United States including Texas and Louisiana
RP	Return period, in years
RV	Random vibration. Abbreviation used for a class of ground motion models also called stochastic models.

S	Site factor used in the regression analysis for G-Expert 5's GM model: S = 0 for deep soil, S = 1 for rock sites
SC	South Central; Region 4
SE	South East; Region 2
S-Expert	One of the eleven experts who provide the zonations and seismicity models used in the analysis
SEP	Systematic Evaluation Program
SHC	Seismic Hazard Characterization
SHCUS	Seismic Hazard Characterization of the United States
SN	Site Number
Spectra	Specifically in this report: attenuation models for spectral ordinates were for 5% damping for the pseudo-relative velocity spectra in PSRV at five frequencies (25, 10, 5, 2.5, 1 Hz).
SSE	Safe Shutdown Earthquake
SSI	Soil-structure-interaction
SSMRP	Seismic Safety Margins Research Program
UB	Upper bound
UHS	Uniform hazard spectrum (or spectra)
USGS	United States Geological Survey
WUS	The regions in the Western United States where we have strong ground motion data recorded and analyzed

Executive Summary: Volume III

The impetus for this study came from two unrelated needs of the Nuclear Regulatory Commission (NRC). One stimulus arose from the NRC funded "Seismic Safety Margins Research Programs" (SSMRP). The SSMRP's task of simplified methods needed to have available data and analysis software necessary to compute the seismic hazard at any site located in the eastern United States (EUS) in a form suitable for use in probabilistic risk assessment (PRA). The second stimulus was the result of the NRC's discussions with the U.S. Geological Survey (USGS) regarding the USGS's proposed clarification of their past position with respect to the 1886 Charleston earthquake. The USGS clarification was finally issued on November 18, 1982, in a letter to the NRC, which states that:

"Because the geologic and tectonic features of the Charleston region are similar to those in other regions of the eastern seaboard, we conclude that although there is no recent or historical evidence that other regions have experienced strong earthquakes, the historical record is not, of itself, sufficient ground for ruling out the occurrence in these other regions of strong seismic ground motions similar to those experienced near Charleston in 1886. Although the probability of strong ground motion due to an earthquake in any given year at a particular location in the eastern seaboard may be very low, deterministic and probabilistic evaluations of the seismic hazard should be made for individual sites in the eastern seaboard to establish the seismic engineering parameters for critical facilities."

Anticipation of this letter led the Office of Nuclear Reactor Regulation to jointly fund a project with the Office of Nuclear Regulatory Research. The results were presented in Bernreuter et al. in 1985 and the objectives were:

1. to develop a seismic hazard characterization methodology for the entire region of the United States east of the Rocky Mountains (Referred to as EUS in this report).
2. to apply the methodology to selected sites to assist the NRC staff in their assessment of the implications in the clarification of the USGS position on the Charleston earthquake, and the implications of the occurrence of the recent eastern U.S. earthquakes in New Brunswick and New Hampshire.

The methodology used in that 1985 study evolved from two earlier studies LLNL performed for the NRC. One study, Bernreuter and Minichino (1983), was part of the NRC's Systematic Evaluation Program (SEP) and is simply referred hereafter to as the SEP study. The other study was part of the SSMRP.

At the time (1980-1985), an improved hazard analysis methodology and EUS seismicity and ground motion data set were required for several reasons:

- o Although the entire EUS was considered at the time of the SEP study, attention was focused on the areas around the SEP sites--mainly in the Central United States (CUS) and New England. The zonation of other areas was not performed with the same level of detail.
- o The peer review process, both by our Peer Review Panel and other reviewers, identified some areas of possible improvements in the SEP methodology.
- o Since the SEP zonations were provided by our EUS Seismicity Panel in early 1979, a number of important studies have been completed and several significant EUS earthquakes have occurred which could impact the Panel members' understanding of the seismotectonics of the EUS.
- o Our understanding of the EUS ground motion had improved since the time the SEP study was performed.

By the time our methodology was firmed up, the expert opinions collected and the calculations performed (i.e. by 1985), the Electric Power Research Institute (EPRI) had embarked in a paralleled study.

We performed a comparative study (Bernreuter et al. 1987) whose purpose was to help in understanding the reasons for differences in results between the LLNL and the EPRI study (EPRI 1985a and 1985b). The three main differences were found to be (1) the minimum magnitude value of the earthquakes contributing to the hazard in the EUS, (2) the ground motion attenuation models, and (3) the fact that LLNL accounted for local site characteristics and EPRI did not. Several years passed between the 1985 study and the time when NRC actually decided to apply the methodology to all the sites in the EUS. In recognition of the fact that during that time a considerable amount of research in seismotectonics and in the field of strong ground motion prediction, in particular with the development of the so called random vibration or stochastic approach, NRC decided to follow our recommendations and have a final round of feedback with all our experts prior to finalizing the input to the analysis.

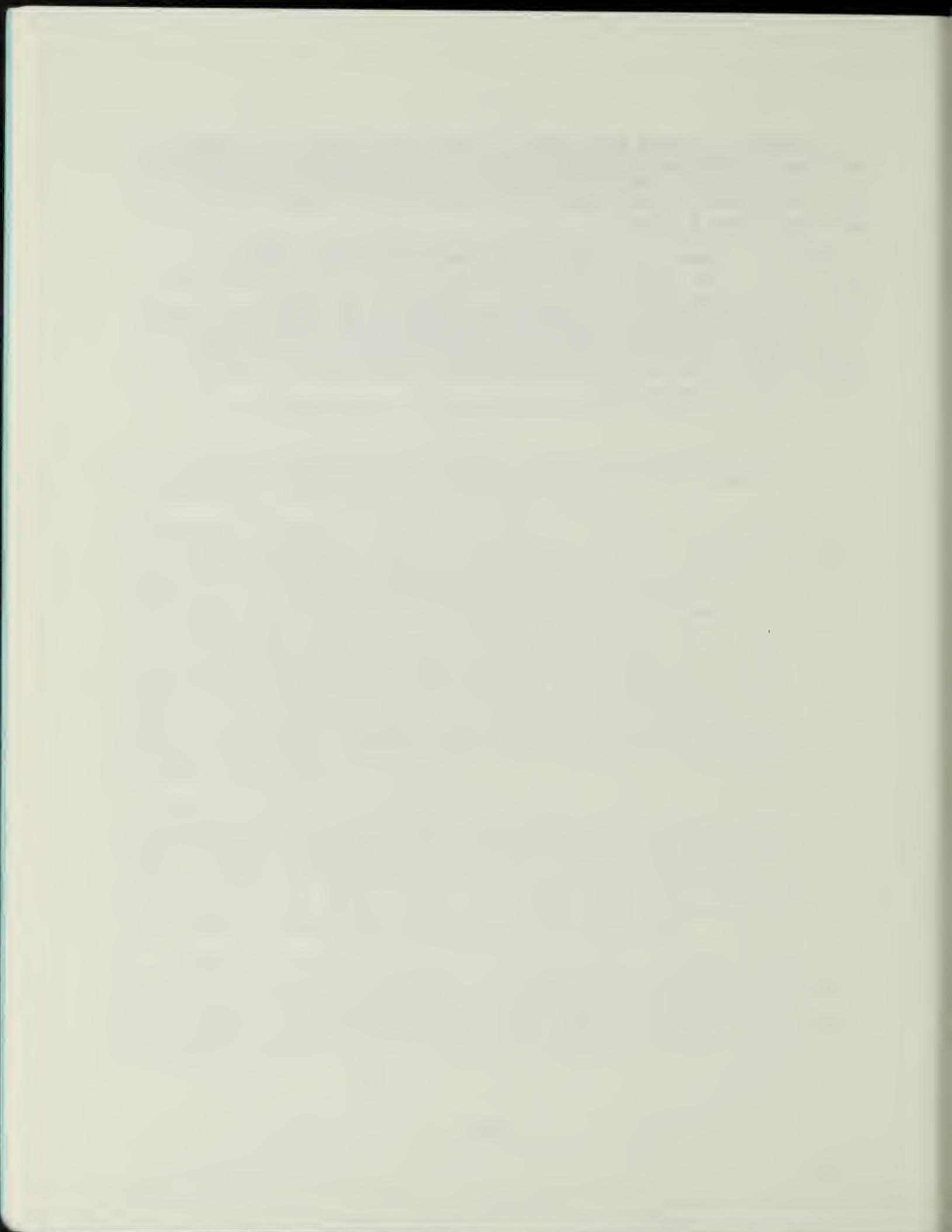
In addition, we critically reviewed our methodology which lead to minor improvements and we also provided an extensive account of documentation on the ways the experts interpreted our questionnaires and how they developed their answers. Some of the improvements were necessitated by the recognition of the fact that the results of our study will be used, together with results from other studies such as the EPRI study or the USGS study, to evaluate the relative hazard between the different plant sites in the EUS.

This volume (volume III) is one of eight volumes where the methodology and the results of the analysis are presented. The analysis was performed for a total of 69 different geographic locations. These sites were divided into four groups (batches) of approximately equal size. Volume III presents the results for the group of sites roughly located in the Southeastern part of the EUS. It contains 17 sites.

The results are presented individually for each site together with comments. The seismic hazard results presented here account for earthquakes of magnitude 5 or above only, and a set of calculations was made to provide an estimate of the seismic hazard created at each of the sites by the earthquakes of magnitude between 3.75 and 5.

In addition, a discussion on uncertainty, comparison between sites, sensitivity to site location and a discussion on the factors influencing the distribution of the contributing zones, is presented in Section 3.

The other volumes provide an extensive description of the methodology (Volume I), the results for the other groups of sites (Volume II, IV and V), a summary and some comparisons between sites and groups of sites (volume VI), and finally a copy of all the questionnaires used in the analysis to develop the input is given in Volume VII.



1. INTRODUCTION

In this Volume we present the seismic hazard estimates for the 17 sites in Batch 2 listed in Table 1.1 and plotted in Fig. 1.1. The seismic hazard results for the Batch 2 sites are based on:

- o The zonation and seismicity inputs provided by our eleven S-Experts listed in Table 1.2.
- o The ground motion models (peak ground acceleration (PGA) models and 5 percent damped velocity spectral models) provided by our five G-Experts listed in Table 1.3.
- o The methodology we developed is described in Vol. I of this report and in other documents referenced in Vol. 1.

The results presented in this report differ from our previous results Bernreuter et al. (1984, 1985, 1987) because for the following reasons:

- o This analysis used the final updated input from our S and G-Experts given in Section 3 and Appendix B of Vol. I. As discussed in Vol. I, S-Experts 3,6,7 and 12 provided completely new zonations and seismicity parameters, S-Experts 4,10,11 and 13 modified some of their zones and seismicity parameters, S-Experts 1,2 and 5 did not make any changes, and the G-Experts significantly changed their ground motion models. The seismic zonation maps are reproduced here in Appendix B.
- o A lower bound of integration of $m_b = 5.0$ was used, i.e., we only included the contribution from earthquakes with magnitude 5.0 and greater. In our previous reports, Bernreuter et al. (1984, 1985), we used a lower bound of 3.75. This change has a significant impact on the results as discussed in Bernreuter et al. (1987). A set of plots for every site giving an indication of how much the earthquakes in the magnitude range 3.75 to 5 would contribute to the seismic hazard estimates is given in the report.

Corrections for the soil conditions at each site have been included using the approach outlined in Section 3.7 of Vol. I. However, it is important to note that each site is put in a single fixed site soil category as listed in Table 1.1. At some sites, some structures, (e.g., the main containment buildings) are founded on rock but some structures are founded on shallow soil (e.g. tanks, pump buildings). The seismic hazard estimates given in this report are at the free surface and in the case of shallow rock sites, it is at the free surface of the rock with the soil removed. Thus for these rock sites which have a few structures founded on shallow soil the results presented here should then be corrected for the shallow soil amplification effects as described in Vol. I before the results given in this report are applied to the structures founded on soil. If all structures are founded on the same soil condition, then no added correction is needed.

Section 2 of this report contains the results for each site and, some site specific discussion. In section 3 of this report we make regional observations and comparisons between sites as well as some comments on sensitivity to site regional location and distance bins contribution. In Vol. VI we reach overall conclusions based on the regional results presented in this volume and Vols. II, IV and V, and Volume VII provides an unaltered copy of all the questionnaires used in this analysis to develop the input.

Volume VIII gives the results for the sites which have several soil conditions at the plant location. Such is the case of Browns Ferry, Catawba, Farley, North Anna, Oconee and Summer.

TABLE 1.1
SITES AND SOIL CATEGORY USED FOR EACH SITE
IN BATCH 2

<u>SITE NAME</u>	<u>Map (1) KEY</u>	<u>SOIL CATEGORY (2)</u>
1. Bellefonte	1	Rock **
2. Browns Ferry	2	Rock **
3. Brunswick	3	Till-like 2
4. Calvert Cliffs	4	Deep soil
5. Catawba	5	Rock
6. Farley	6	Rock **
7. Hatch	7	Deep soil
8. McGuire	8	Rock
9. North Anna	9	Rock
10. Oconee	A	Rock
11. Robinson	B	Deep soil
12. Sequoyah	C	Rock
13. Shearon Harris	D	Rock
14. Summer	E	Rock
15. Surry	F	Deep soil
16. Vogtle	G	Deep soil
17. Watts Bar	H	Rock

(1) Key used on Fig. 1.1.

(2) Site categories as given in Table 1.4 (repeated from Table 3.9 of Vol. I)

(**) Have structures founded in shallow soil.

TABLE 1.2
FINAL EUS ZONATION AND SEISMICITY PANEL MEMBERS
(S-Panel)

Professor Gilbert A. Bollinger
Mr. Richard J. Holt
Professor Arch C. Johnston
Dr. Alan L. Kafka
Professor James E. Lawson
Professor L. Tim Long
Professor Otto W. Nuttli
Dr. Paul W. Pomeroy
Dr. J. Carl Stepp
Professor Ronald L. Street
Professor M. Nafi Toksöz

TABLE 1.3
FINAL EUS GROUND MOTION MODEL PANEL MEMBERS
(6-Panel)

Dr. David M. Boore
Dr. Kenneth Campbell
Professor Mihailo Trifunac
Dr. John Anderson
Dr. John Dwyer

TABLE 1.4
DEFINITION OF THE EIGHT SITE CATEGORIES

		<u>CATEGORY</u>	<u>DEPTH</u>
	Generic Rock		
(1)		Rock	N/A
	Sand Like		
(2)	Sand 1	S1	25 to 80 ft.
(3)	Sand 2	S2	80 to 180 ft.
(4)	Sand 3	S3	180 to 300 ft.
	Till-Like		
(5)	Till 1	T1	25 to 80 ft.
(6)	Till 2	T2	80 to 180 ft.
(7)	Till 3	T3	180 to 300 ft.
	Deep Soil		
(8)		Deep Soil	N/A

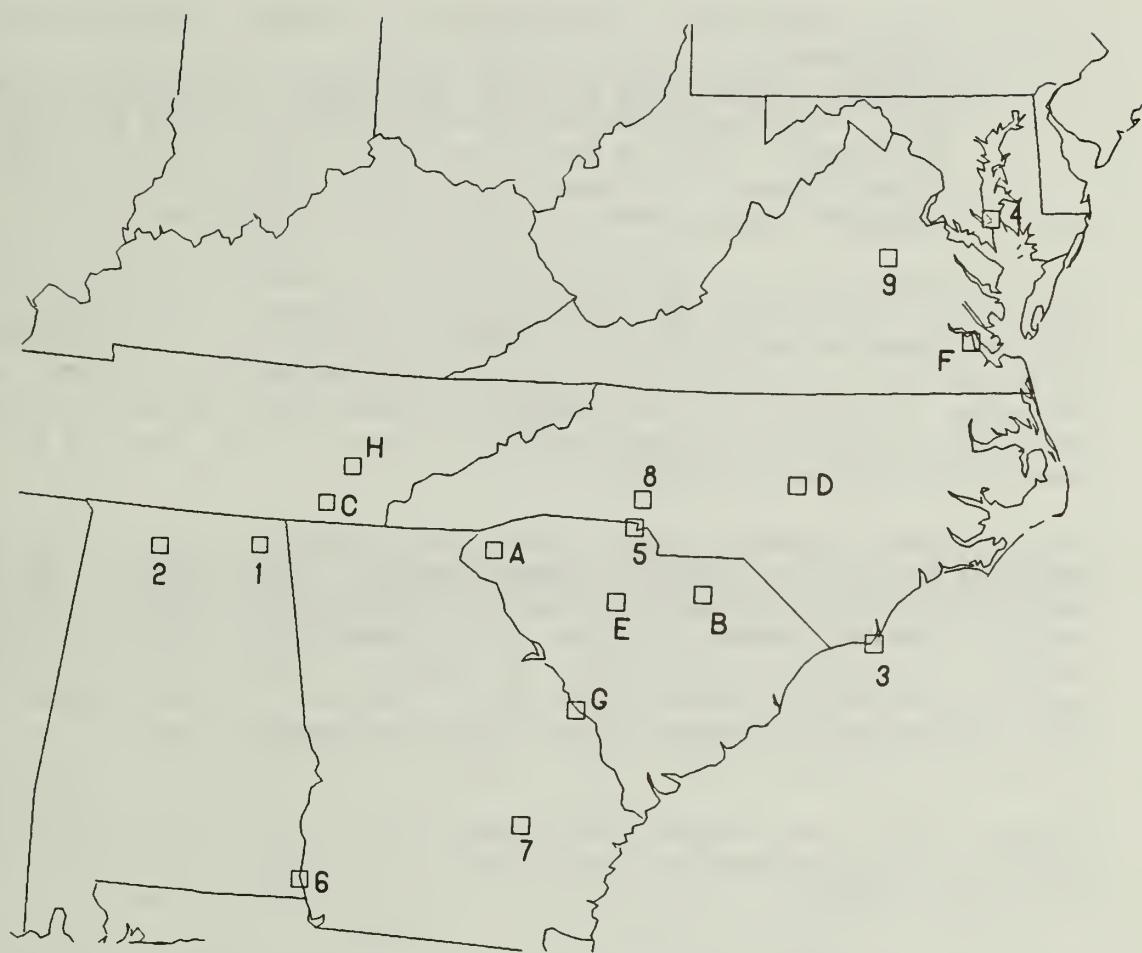


Figure 1.1 Map showing the location of the Batch 2 sites contained in Vol. III of this report. Map symbols are given in Table 1.1.

2. RESULTS AND SITE SPECIFIC DISCUSSION

2.0 General Introduction

In sections 2.1 to 2.17 we provide the results for the sites listed in Table 1.1. Using a uniform format for each site (i.e. each section) we first present table 2.SN.1 (where "SN" stands for Site Number) providing the following information:

- o Soil category used in the analysis to correct for local site conditions.
- o For each S-Expert table 2.SN.1 provides a listing of the four seismic zones which contribute most to the hazard in terms of the peak ground acceleration (PGA) at both lower PGA (0.125g) and at higher PGA (0.6g) values. The zone ID's listed in the tables are keyed to the S-Experts' maps given in Appendix B of this Volume.

The contribution of various zones given in the table for each site is limited only to the contribution to the best estimate hazard curves (BEHCs). That is, only the zones on the BE map (i.e. those zones which have a probability of existence of 0.5 or greater) and only the BE PGA models are used. This, as discussed in Section 3.3, is a limitation that should be kept in mind as in a few cases zones with a probability of existence of less than 0.5 which may contribute might not be listed.

The table is followed by ten figures, 2.SN.1 to 2.SN.10 (SN = Site Number given in Table 1.1). The first three figures, Figs. 2.SN.1 - 2.SN.3 give various PGA hazard curves. The next six figures, Figs. 2.SN.4 - 2.SN.9 give various 5 percent damped relative velocity spectra for various return periods. It should be noted that the spectral calculations have only been made at five periods, 0.04s, 0.1s, 0.2s, 0.4s and 1.0s and straight lines have been used to connect these points to get the shapes plotted.

Figures 2.SN.1 give a comparison between the best estimate hazard curve (BEHC), and the arithmetical mean hazard curve (AMHC) for the peak ground acceleration (PGA).

The BEHC and the AMHC are aggregated over all S- and G-Experts and include the experts' self weights. Reference should be made to Section 2 and Appendix C of Vol. 1 for a discussion about these two estimators. Briefly, in our elicitation process we asked each S-expert to indicate which set of zones he considered his "best estimate" in the sense that it represented the mode of the distribution of all of his choices and similarly for the best estimate values for all of the seismicity parameters for each zone. We also asked each G-Expert to indicate which ground motion model represented his best estimate model. Then, as indicated in Vol. I, the set of best estimate zones and

seismicity parameters are used with each of the best estimate ground motion models to generate 55 BEHCs'. These 55 curves are then aggregated using both the S- and G-Experts' self weights. The AMHC is generated in the usual manner using all 2750 simulations of the Monte Carlo analysis.

Figures 2.SN.2 give the BEHC for each S-Expert aggregated over the five G-Experts. Whenever individual S-Experts' hazard curves are plotted they are denoted by the plot key given in Table 2.0. Figures 2.SN.2 give a measure of the range of difference of opinion between the eleven S-Experts.

Figures 2.SN.3 give the 15th, 50th and 85th constant percentile hazard curves (CPHCs) based on all 2750 simulations and give a measure of the overall uncertainty.

Figures 2.SN.4 give the contribution to the BEHC (aggregated over all S- and G-Experts) for earthquakes in four magnitude ranges:

<u>Curve Number</u>	<u>Magnitude Range</u>
1	$3.75 \leq m_b \leq 5$
2	$5 < m_b \leq 5.75$
3	$5.75 < m_b \leq 6.5$
4	$6.5 \leq m_b$

The curves are useful to indicate the relative contribution of smaller, moderate and large earthquakes to the seismic hazard and how much higher the estimated seismic hazard would be if the contribution of smaller earthquakes in the range 3.75 to 5.0 were included.

Figures 2.SN.5 give the best estimate uniform hazard spectra (BEUHS) for return periods of 500,1000,2000,5000, and 10,000 years, aggregated over all S and G-Experts.

Figures 2.SN.6 give the 1000 year return period BEUHS for each of the S-Experts, aggregated over the G-Experts. The S-Experts' BEUHS are plotted using the symbols in Table 2.0. These plots give a good measure of the significance of the differences in opinion between the S-Experts.

Figures 2.SN.7,8,9 give the 15th, 50th and 85th constant percentile uniform hazard spectra (CPUHS) aggregated over all S and G-Experts for return periods of 500,1000 and 10,000 years. The spread between the 15th and 85th CPUHS gives a good measure of the overall uncertainty in the estimate of the seismic hazard at the site.

Figures 2.SN.10 give the 50th CPUHS for return periods of 500,1000,2000, 5000 and 10,000 years, aggregated over all S and G-Experts.

For some sites, such as Bellefonte, additional figures (i.e., Figures 2.SN.11 and/or 2.SN.12) were given to demonstrate specific points.

A separate discussion is given when some factors of interest are noted. In Section 3 comparisons between the sites and general observations are made.

TABLE 2.0
PLOT SYMBOL KEY USED FOR INDIVIDUAL
S-EXPERTS ON FIGS. 2.SN.2 and 2.SN.6

<u>Expert No.</u>	<u>Plot Symbol</u>
1	1
2	2
3	3
4	4
5	5
6	6
7	7
10	A
11	B
12	C
13	D

2.1 BELLEFONTE

Bellefonte is a rock site and is represented by the symbol "1" in Fig. 1.1. Table 2.1 and Figs. 2.1.1. to Figs. 2.1.10 give the basic results for this site. The AMHC shown in Fig. 2.1.3 is close to the 85th percentile CPHC.

The distribution of the hazard appears to be roughly symmetrical (see Fig. 2.1.3) thus showing that for this site no particular outlier GM model dominates.

Figure 2.1.4 indicates that most of the hazard is coming from earthquakes greater than $m_b = 6.5$. It also suggests that the hazard curve would only change for PGA values less than 0.15g if earthquakes in the range $3.75 \leq m_b \leq 5$ were to be included.

Table 2.1.1 shows that for 6 out of the 11 S-Experts, the zone which contributes the most to the hazard at 0.125g is the host zone (i.e. the zone within which the site is located). At 0.6g it is for 5 out of 11 S-Experts.

For S-Experts 2,4,5 and 7, which appear to be the "high" experts in this case, a distant zone (i.e. the New Madrid zone), with generally high recurrence rate and high upper magnitude cutoff dominates at low and at high PGA. In the case of S-Expert 1, the dominant zone at low PGA is the host zone (i.e. zone 4) and at high PGA it is the distant New Madrid zone.

Prior to expanding on this, the reader must recall (see Vol. 1, Appendix C) that the percent contributions tabulated in Tables 2.SN.1 (SN stands for "site number", i.e. Table 2.1.1) is calculated only for the Best Estimate case (where all the uncertain parameters are fixed and set to their best estimate value, including using the best estimate map (BEM) for each S-Expert and the best estimate GM model for each G-Expert). This "percent contribution" is not, strictly speaking a percent since it is the normalized ratio of the hazard contributed by the particular zone to the total hazard, and the rule of hazard addition over all zones is not a linear operation as shown by equation 2.7 in Volume I, Section 2.

The BEHC are aggregated over the G-Experts (Per S-Expert) arithmetically so that a high outlier tends to dominate the results. G-Expert 5's ground motion model leads to BEHCs that are high outliers (relative to the other G-Experts' BEHCs per S-Expert) at the Bellefonte site. G-Expert 5's BEHCs are high in the sense indicated for several reasons.

- (1) Most importantly, as discussed in Vol. 1 Section 3.5, for the same distance and magnitude, the Model G16-A3 (G-Expert 5's choice for BE

GM model) is higher by a factor of 2 relative to the other BE GM models for rock sites. A factor of 2 in PGA results is approximately a factor of 8-10 in probability of exceedance (see also Volume VI, Section 2.3 for details).

- (2) It can be seen from Fig. 3.4 in Vol. I that G-Expert 5's BE PGA (GM model G16-A3) has significantly lower attenuation than the other models particularly at the larger magnitudes. This coupled with the site correction factor for rock increases the contribution from distance zones which have larger earthquakes. For example, a simple calculation would show that for G-Expert 5's model, earthquakes of $m_b = 6.0$ have the same PGA at 100 km as $m_b = 5$ earthquakes at 20 km.
- (3) G-Expert 5 sets the random uncertainty (standard deviation on the natural log of the PGA) at 0.7 compared to the range of values (0.35 - 0.55) selected by the other G-Experts. Relative to results obtained with a value of 0.55, this larger uncertainty (0.7) leads to an increase in the G-Expert 5's BEHC by about a factor of 2 in probability of exceedance at lower g-values (0.2g) to over a factor of 3 at high g-values (0.9g)

In summary we typically expect at rock sites that BEHC for G-Expert 5 for any S-Expert will be about a factor of 10-20 higher in probability of exceedance relative to the other BE GM models (factors (1) and (3) noted above) as illustrated in Fig. 2.1.11 where the BEHCs per G-Expert for S-Expert 1's seismicity input are plotted.

As a result of the above the probability distribution of the hazard estimated from the Monte Carlo simulation appears to be slightly skewed towards the higher values of probability of exceedance. Although this phenomenon is not very apparent when all the S-Experts have been combined (i.e., Fig. 2.1.3), it is apparent for some individual S-Experts, such as S-Expert 4, as shown in Fig. 2.1.12. This is the case where the zone that contains the site has a low upper magnitude cutoff and a near-by zone which has a significantly larger upper magnitude cutoff. In this case the low attenuation of model G16-A3 becomes very important and G-Expert 5's BEHC becomes significantly larger (relative to the typical case illustrated in Fig. 2.1.11) than the other BEHCs per G-Expert for a given S-Expert's input. It can be seen from Table 2.1.1 and the map for S-Expert 4 in Appendix B, that, zone 4 which contribute most to the hazard is some distance from the site. The upper magnitude cutoff in zone 3 which contains the site is only 5.5 whereas it is 7.5 for zone 4 (New Madrid).

Figure 2.1.6 shows the 1000 year return period best estimate uniform hazard response spectra for 5% damping for all the S-Experts. These 11 curves show a rather even spread with some departure from the overall trend at 1 sec period for Expert 11 (symbol "B"). For this expert, almost all of the hazard is contributed by the host zone (zone 6) from the very near site areas of the

zone. Furthermore, this contribution comes from earthquakes in the low to medium magnitude range (i.e. 5 to 6.5) as opposed to high (i.e. above 6.5). Thus observing the behavior of the GM spectra models in Figs. 3.7 and 3.8 of Volume I we see that the BEUHS for S-Expert 11 will be lower at 1 sec. than at .4 sec. This set of circumstances does not appear for the other S-Experts at this site.

TABLE 2.1.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR BELLEFONTE

SITE	SOIL	CATEGORY	ROCK	S-XPRT	HOST NUM.	ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)
1	ZONE 4	ZONE ID: ZONE 4 % CONT.: 42.	ZONE 9 ZONE 39.	ZONE 10 ZONE 3.	ZONE 11 ZONE 3.	ZONE 9 ZONE 69.	ZONE 4 29.
2	ZONE 27	ZONE ID: ZONE 18 % CONT.: 50.	ZONE 27 ZONE 32.	ZONE 30 ZONE 13.	ZONE 20 ZONE 3.	ZONE 18 ZONE 76.	ZONE 27 22.
3	ZONE 5	ZONE ID: ZONE 5 % CONT.: 73.	ZONE 13 ZONE 15.	ZONE 9 ZONE 9.	ZONE 12 ZONE 1.	ZONE 9 ZONE 94.	ZONE 13 ZONE 5.
4	ZONE 13	ZONE ID: ZONE 4 % CONT.: 66.	ZONE 8 ZONE 15.	ZONE 28 ZONE 9.	ZONE 10 ZONE 3.	ZONE 4 ZONE 79.	ZONE 12 ZONE 16.
5	ZONE 11	ZONE ID: ZONE 15 % CONT.: 49.	ZONE 11 ZONE 36.	ZONE 9 ZONE 12.	ZONE 14 ZONE 2.	ZONE 14 ZONE 67.	ZONE 11 ZONE 31.
6	ZONE 12	ZONE ID: ZONE 12 % CONT.: 39.	ZONE 17 ZONE 22.	ZONE 13 ZONE 19.	ZONE 18 ZONE 11.	ZONE 12 ZONE 56.	ZONE 13 ZONE 18.
7	ZONE 7	ZONE ID: ZONE 6 % CONT.: 68.	ZONE 7 ZONE 27.	ZONE 5 ZONE 2.	ZONE 10 ZONE 2.	ZONE 15 ZONE 74.	ZONE 11 ZONE 26.
10	ZONE 28	ZONE ID: ZONE 28 % CONT.: 65.	ZONE 12A ZONE 21.	ZONE 19 ZONE 9.	ZONE 13 ZONE 2.	ZONE 28 ZONE 89.	ZONE 13 ZONE 5.
11	ZONE 6	ZONE ID: ZONE 6 % CONT.: 71.	ZONE 11 ZONE 9.	ZONE 8 ZONE 6.	ZONE 10 ZONE 5.	ZONE 6 ZONE 92.	ZONE 11 ZONE 5.
12	ZONE 16	ZONE ID: ZONE 19 % CONT.: 42.	ZONE 17 ZONE 21.	ZONE 16 ZONE 15.	ZONE 15 ZONE 9.	ZONE 19 ZONE 36.	ZONE 16 ZONE 24.
13	ZONE 8	ZONE ID: ZONE 8 % CONT.: 66.	ZONE 5 ZONE 27.	CZ 15 CZ 2.	ZONE 4 ZONE 2.	ZONE 8 ZONE 81.	CZ 15 ZONE 19.
							ZONE 9 0.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

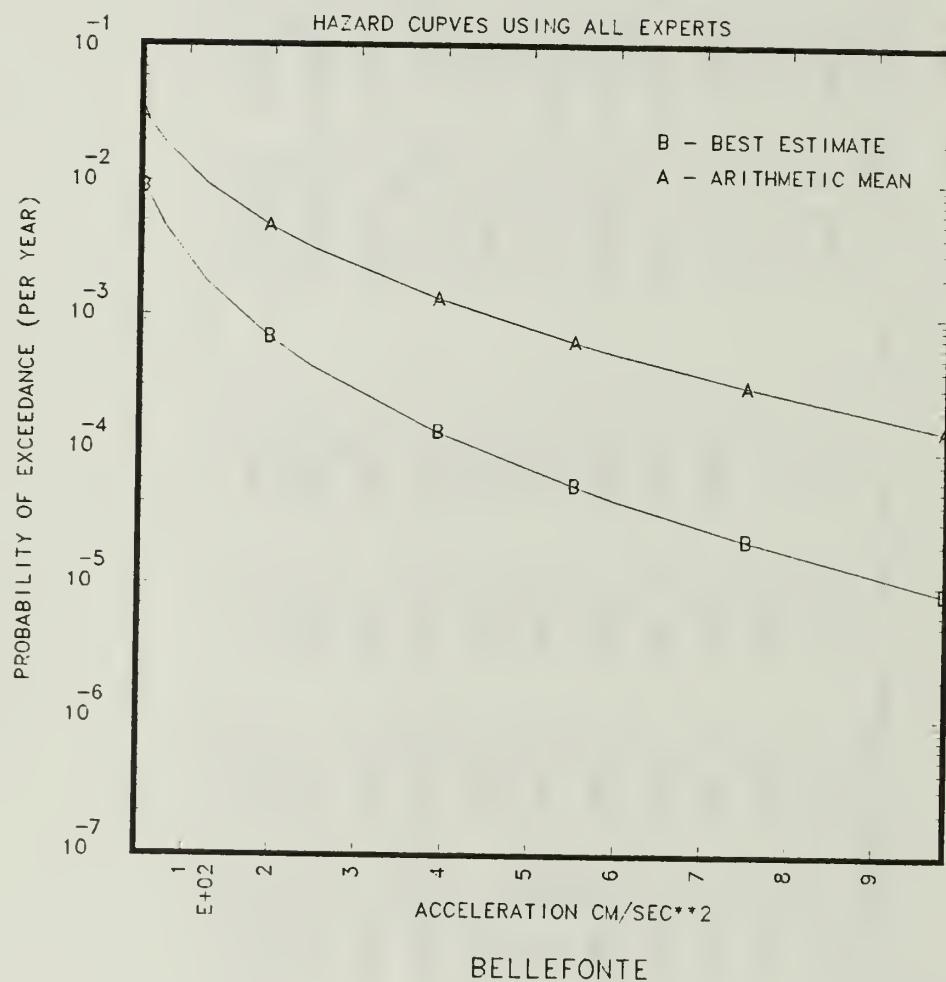


Figure 2.1.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Bellefonte site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

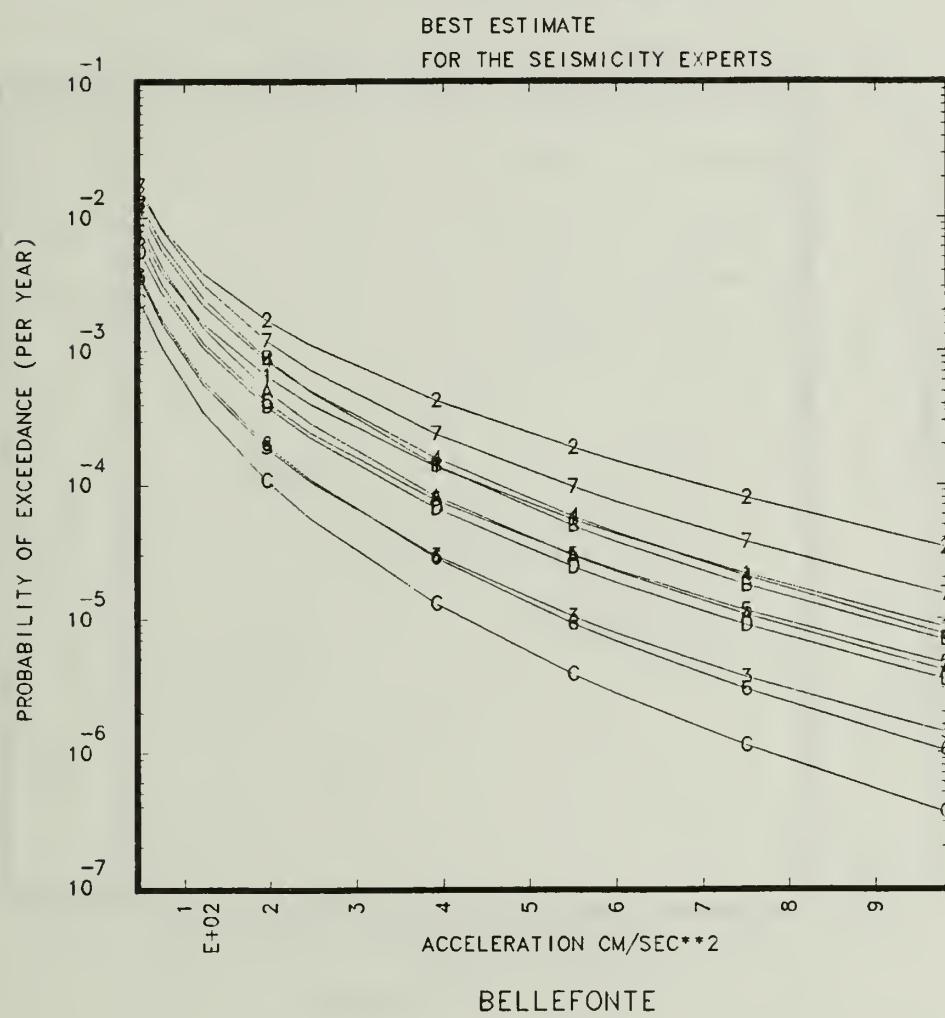


Figure 2.1.2 BEHCs per S-Expert combined over all G-Experts for the Bellefonte site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

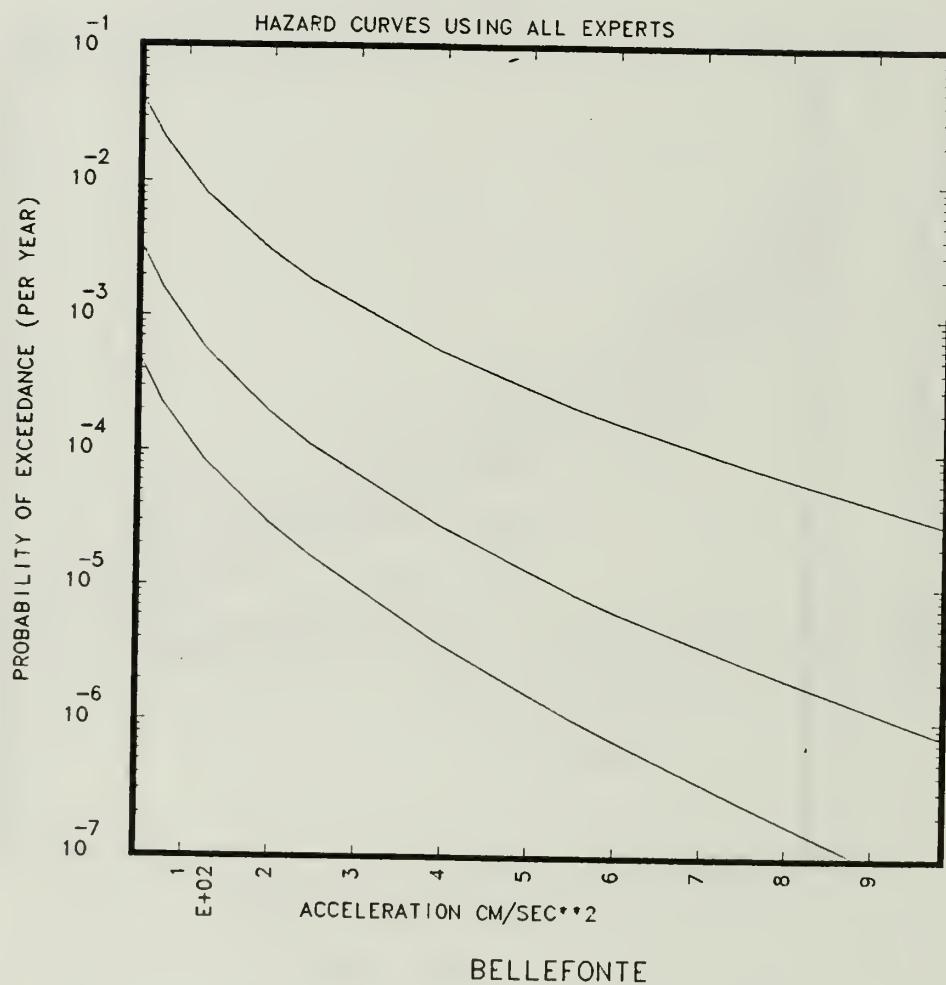


Figure 2.1.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Bellefonte site.

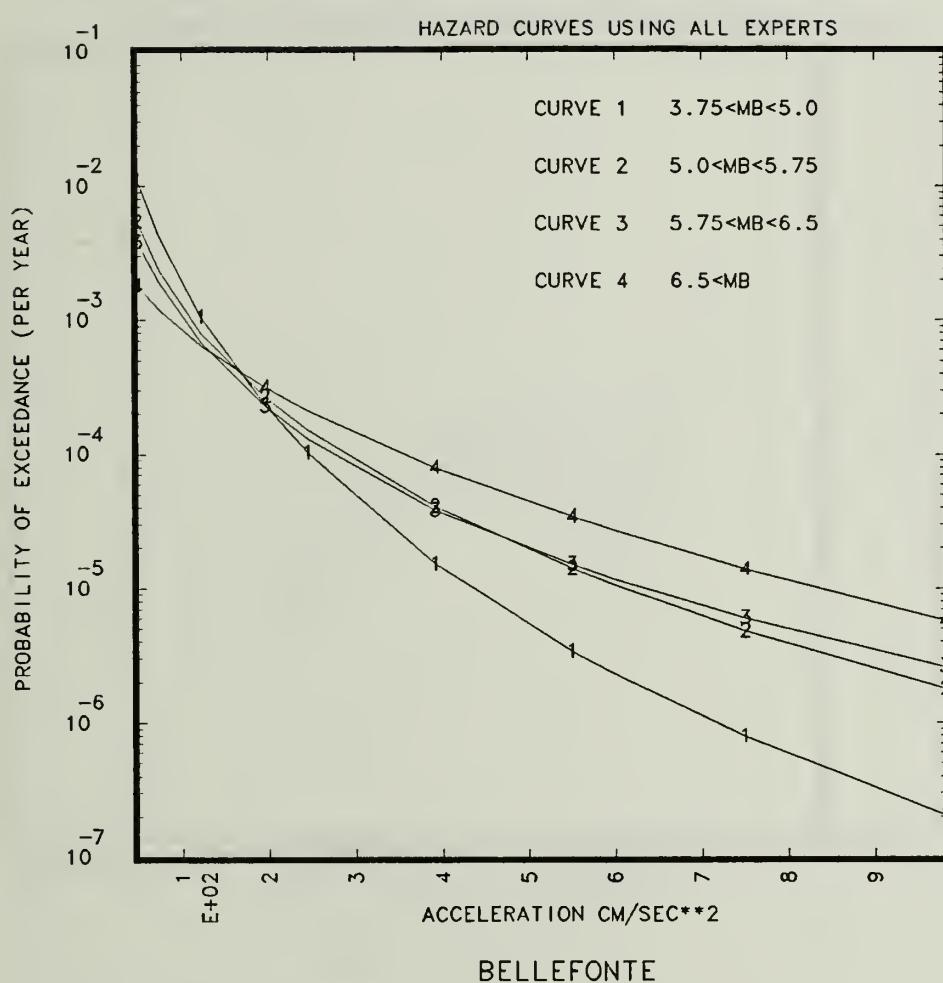


Figure 2.1.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Bellefonte site.

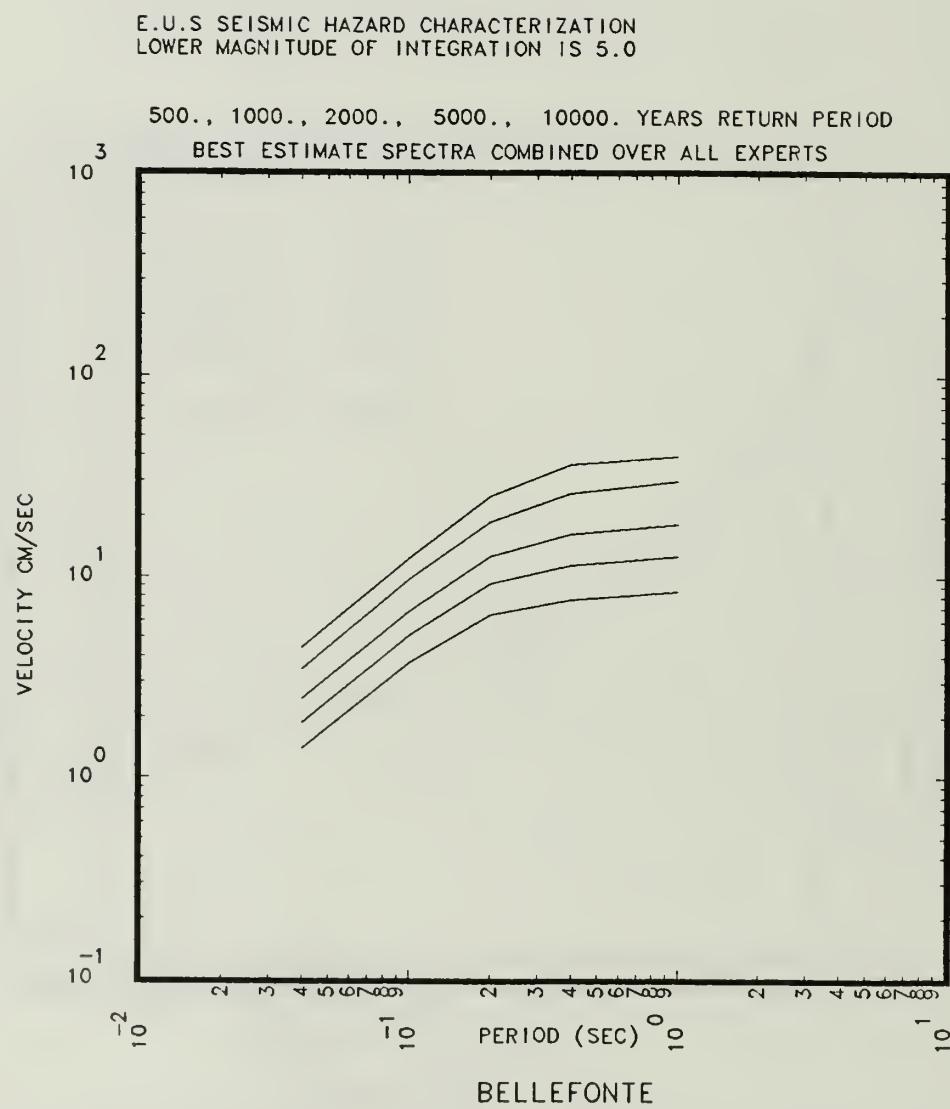


Figure 2.1.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Bellefonte site.

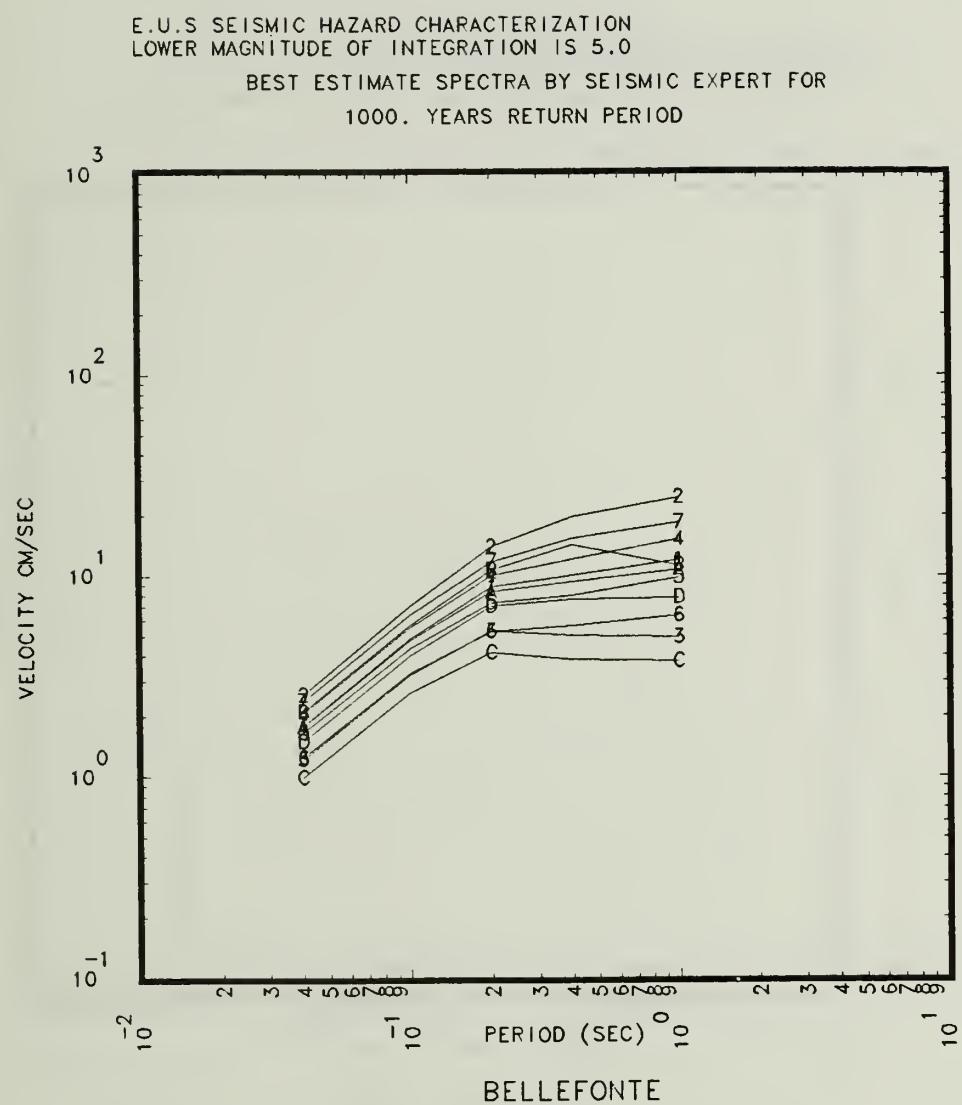


Figure 2.1.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Bellefonte site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

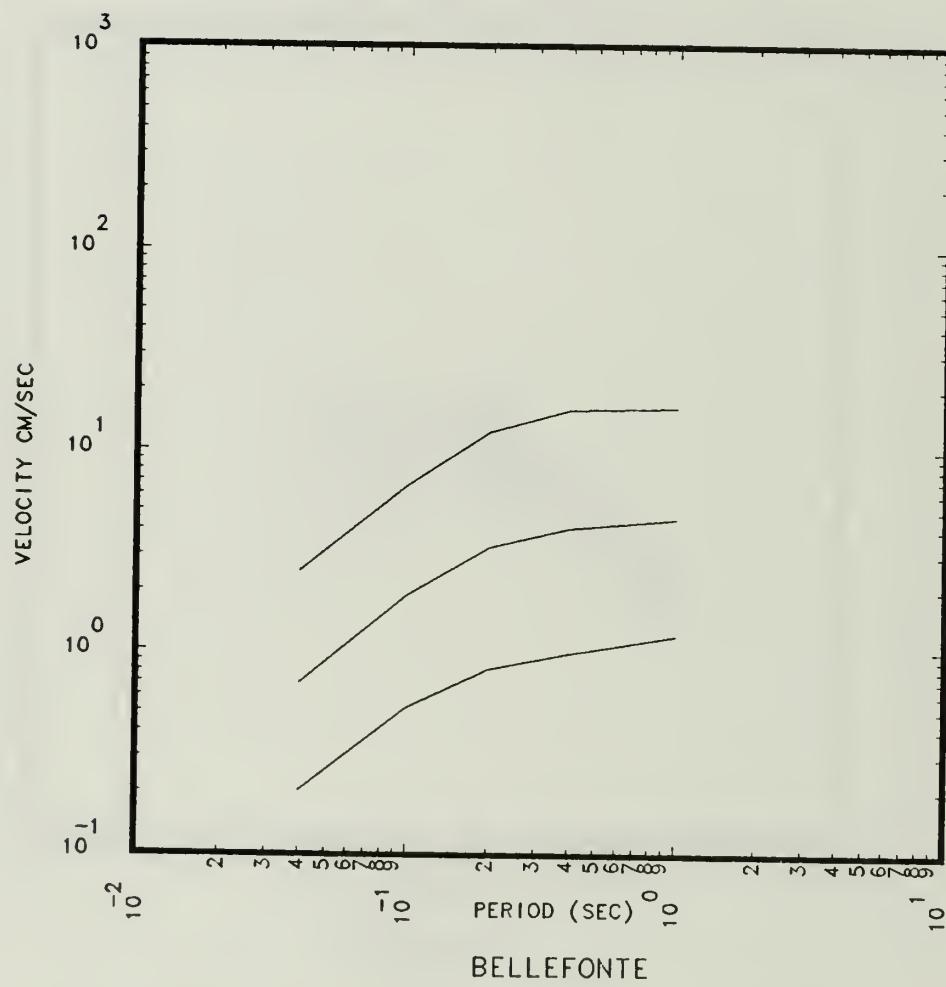


Figure 2.1.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Bellefonte site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

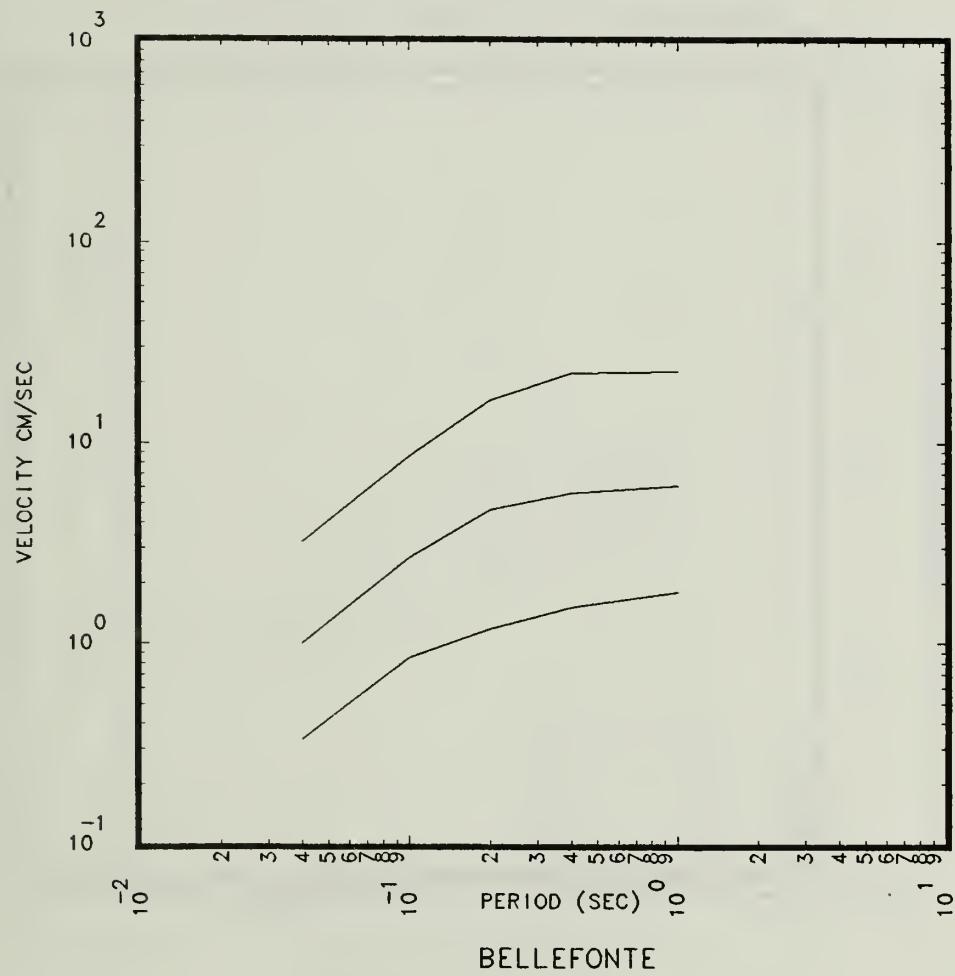


Figure 2.1.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Bellefonte site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

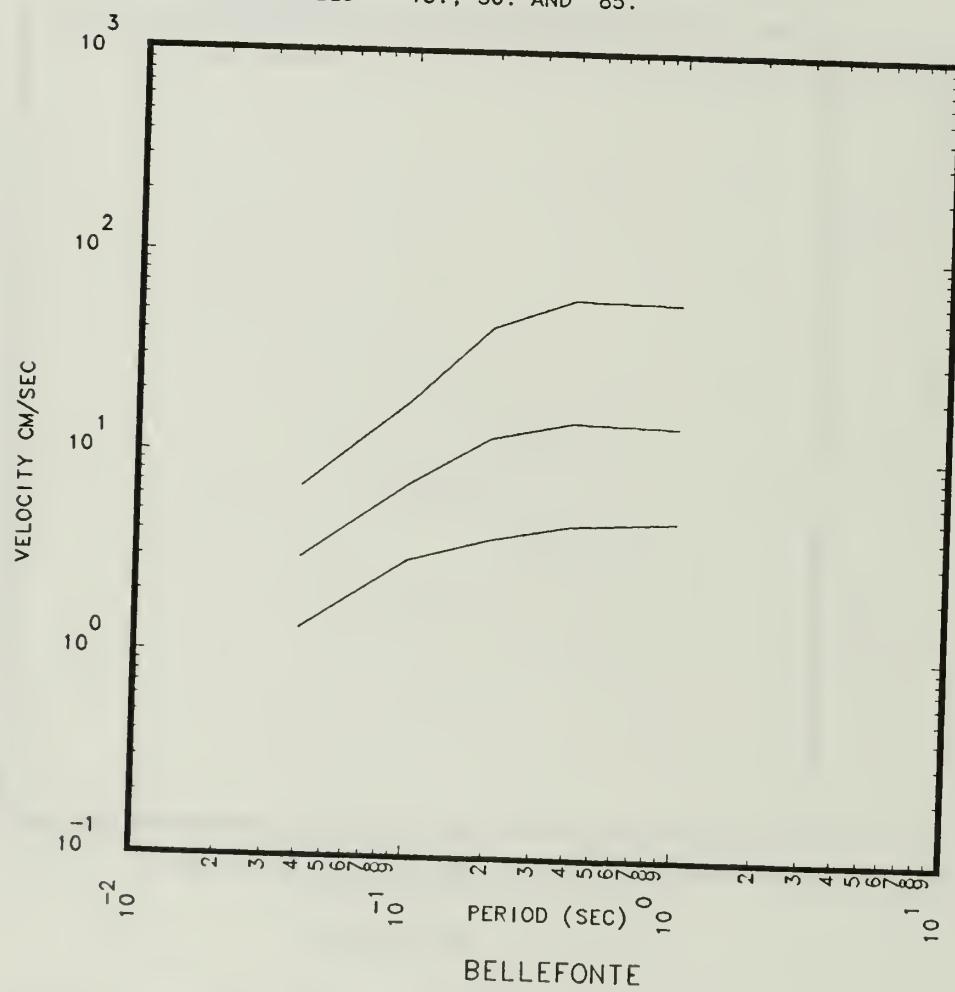


Figure 2.1.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Bellefonte site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

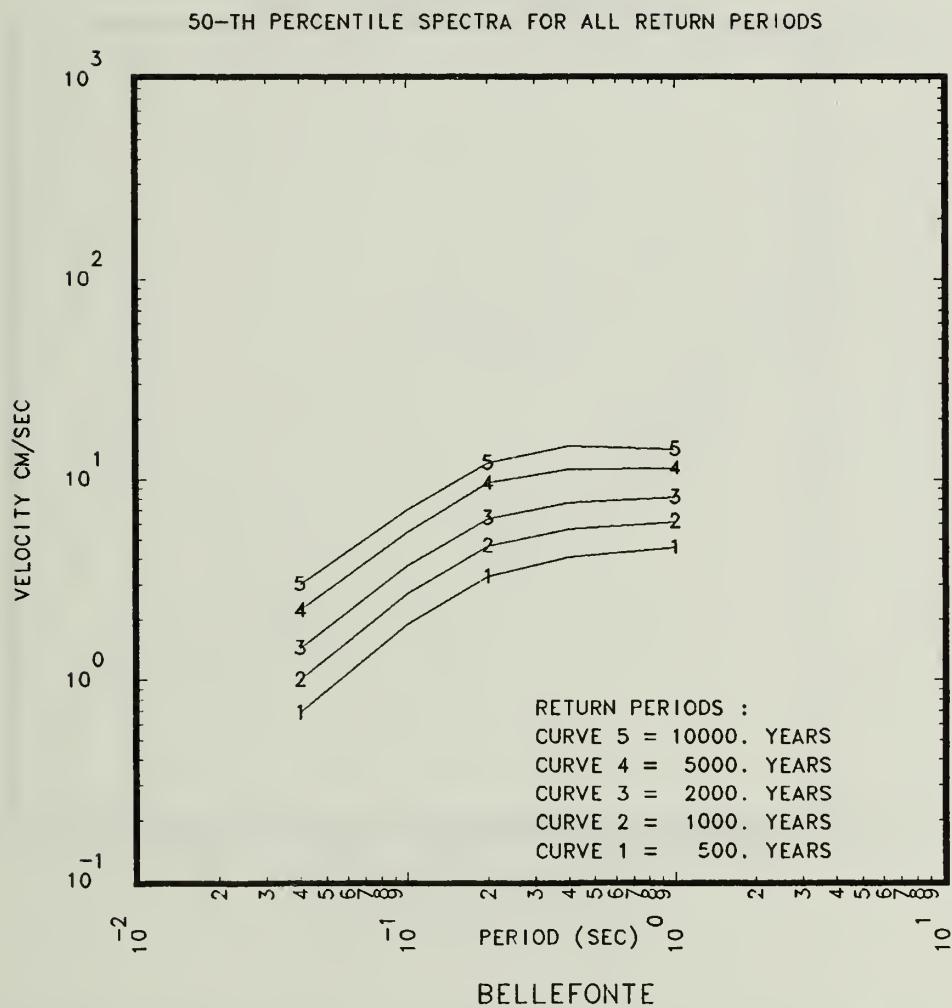


Figure 2.1.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Bellefonte site.

EUS SEISMIC HAZARD CHARACTERIZATION,
LOWER MAGNITUDE OF INTEGRATION = 5.

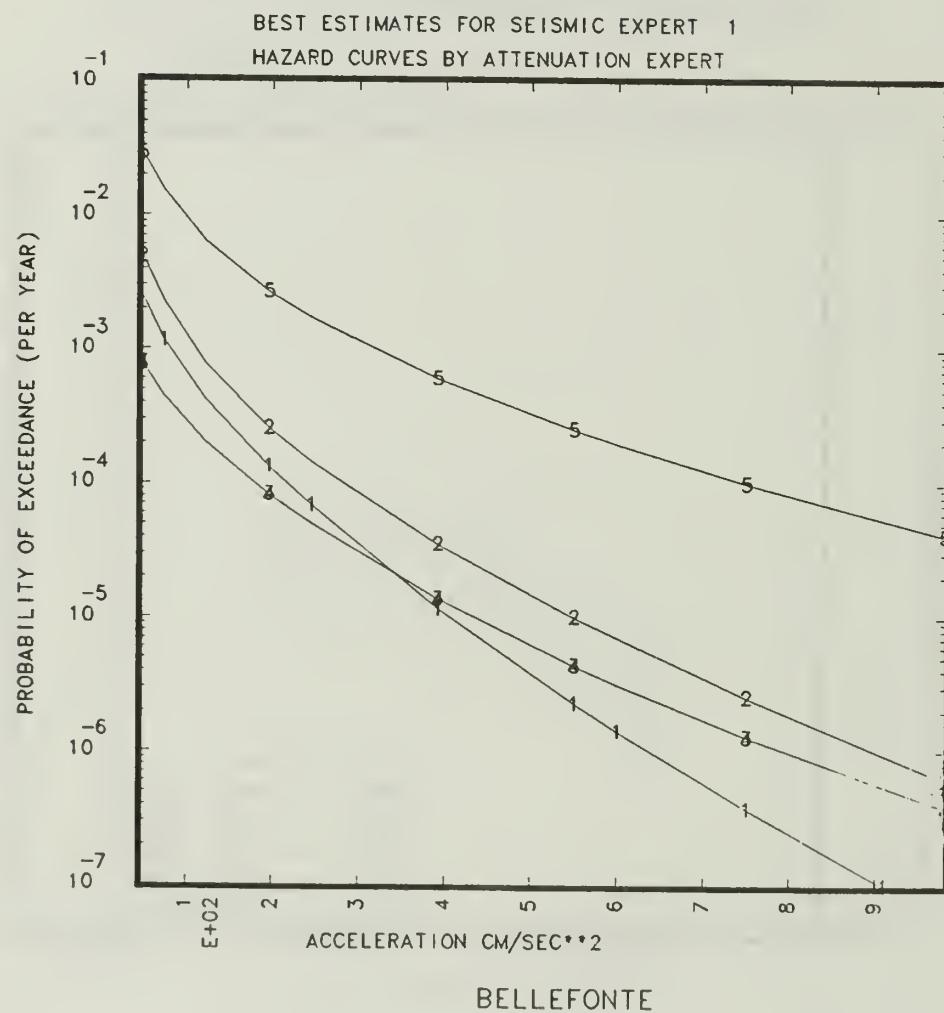


Figure 2.1.11 Comparison of the BEHC for PGA per G-Expert for S-Expert 1's input for the Bellefonte site. The spread between the BEHC for G-Expert 5 and the other S-Expert's BEHC is typical of that at rock sites in Region 2.

EUS SEISMIC HAZARD CHARACTERIZATION,
LOWER MAGNITUDE OF INTEGRATION = 5.

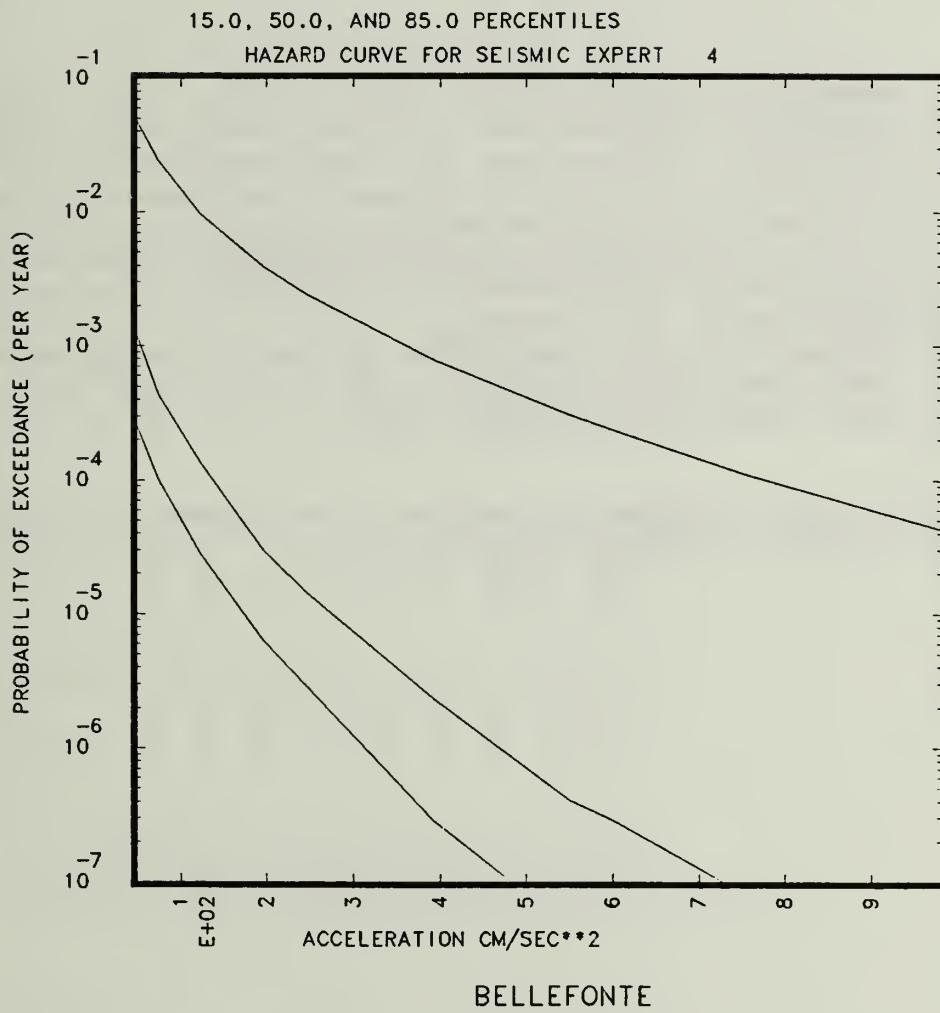


Figure 2.1.12 This figure shows that the probability distribution of the hazard for some S-Experts can be skewed. Here, for S-Expert 4, the skewness is towards higher values of hazard for the Bellefonte site.

2.2 BROWNS FERRY

Browns Ferry is a rock site and is represented by the symbol "2" in Fig. 1.1. Table 2.2.1 and Figs. 2.2.1 to 2.2.10 give the results of the analysis for this site. The AMHC is higher than the 85th percentile and the BEHC is between the 50th and the 85th percentile. This indicates the presence of some outlier curves in the simulation. Table 2.2.1 shows that for most S-Experts, the Browns Ferry site is located inside a complementary zone, with a relatively low upper magnitude cutoffs and low occurrence rates. Thus the dominant zones are distant zones which have high rates of occurrence and higher upper magnitude cutoffs such as the New Madrid zone. Indeed, the hazard comes for its most part from areas located 150 km or more from the site.

S-Expert 12 (symbol "C") appears to be an outlier in Fig. 2.2.2. This is because for this expert, the Browns Ferry site is located in the complementary zone (zone 4) which has a best estimate upper magnitude cutoff of 5.0 (see Table B12.1 in Vol. I), thus the first zones which contribute anything are already distant enough that the ground motion at the site be significantly attenuated, since the analysis only includes earthquakes of magnitude 5.0 and above. Figure 2.2.4 shows that the biggest contribution is from earthquakes greater than magnitude 6.5, with ranges 5.0 - 5.75 and 5.75 - 6.5 contributing equally and earthquakes of magnitude between 3.75 and 5.0 contributing only very little. Hence including earthquakes in that latter range would not have changed the hazard significantly at this site.

The discussion given in Section 2.1 relative to the dominance of G-Expert 5's GM model for the BEHC and AMHC also applies.

MOST IMPORTANT ZONES PER S-EXPERT
FOR BROWNS FERRY

SITE SOIL CATEGORY ROCK

S-XPT NUM.	HOST ZONE	ZONES AT 10W PGA(0.125G)	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT HIGH PGA(0.60G)
1	ZONE 15 % CONT:	ZONE 9 ZONE 4 ZONE 20. 16. 4.	ZONE 11 ZONE 4 ZONE 8. 6.
2	ZONE 27 % CONT:	ZONE 18 ZONE 27 ZONE 30 ZONE 7. 23. 4.	ZONE 18 ZONE 27 ZONE 12. 1.
3	COMP. ZG % CONT:	ZONE 5 ZONE 13 ZONE 12 ZONE 18. 33. 45.	ZONE 5 ZONE 13 ZONE 12 ZONE 6. 3.
4	ZONE 13 % CONT:	ZONE 4 ZONE 8 ZONE 3 ZONE 2. 6.	ZONE 5 ZONE 4 ZONE 8 ZONE 2. 0.
5	COMP. ZG % CONT:	ZONE 15 ZONE 11 ZONE 9 ZONE 8. 78. 9.	ZONE 14 ZONE 15 ZONE 11 ZONE 2. 1.
6	ZONE 12 % CONT:	ZONE 12 ZONE 17 ZONE 18 ZONE 16. 34.	ZONE 13 ZONE 14 ZONE 11 ZONE 10. 1.
7	ZONE 7 % CONT:	ZONE 6 ZONE 7 ZONE 5 ZONE 4. 78.	ZONE 10 ZONE 6 ZONE 7 ZONE 16. 1.
10	ZONE 19 % CONT:	ZONE 12A ZONE 19 = ZONE 28 ZONE 13 ZONE 25. 18.	ZONE 12A ZONE 19 = ZONE 8. ZONE 41. 1.
11	ZONE 12 % CONT:	ZONE 12 ZONE 6 ZONE 11 ZONE 18. 40. 21.	ZONE 10 ZONE 10 ZONE 12 ZONE 11 ZONE 6. CZ = ZONE 2.
12	ZONE 4 = % CONT:	ZONE 15 ZONE 14 ZONE 19 ZONE 17. 29.	ZONE 13 ZONE 15. ZONE 79. 10. 6.
13	CZ 15 % CONT:	ZONE 5 ZONE 8 CZ 15 ZONE 9. 56. 26.	ZONE 4 ZONE 5 ZONE 8 CZ 15 ZONE 17. 12. 0.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

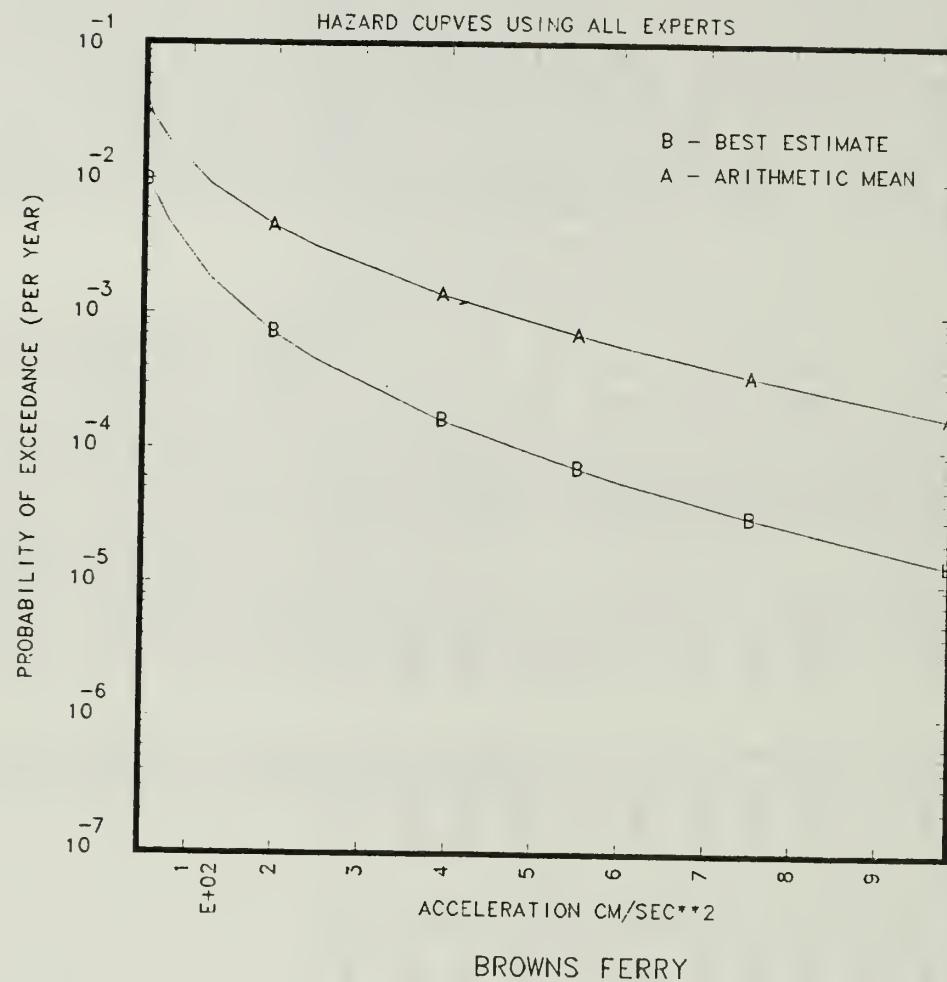


Figure 2.2.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Browns Ferry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

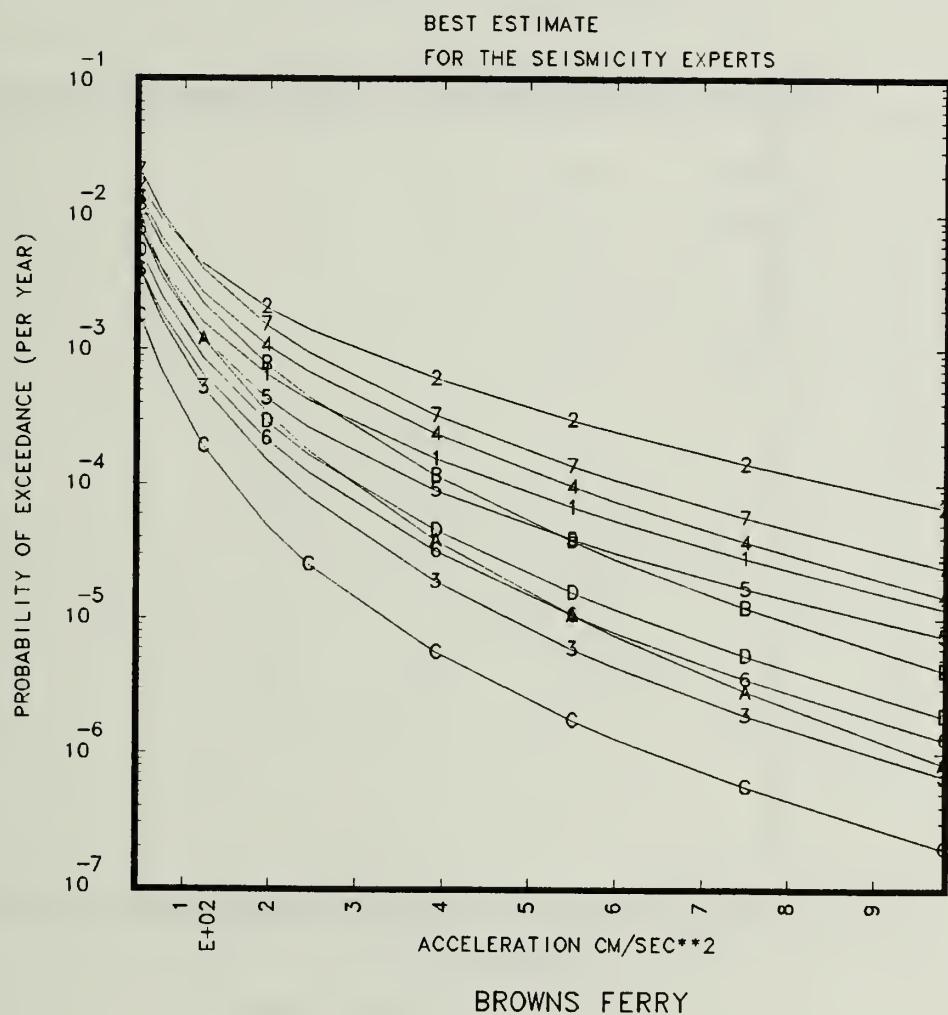


Figure 2.2.2 BEHCs per S-Expert combined over all G-Experts for the Browns Ferry site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

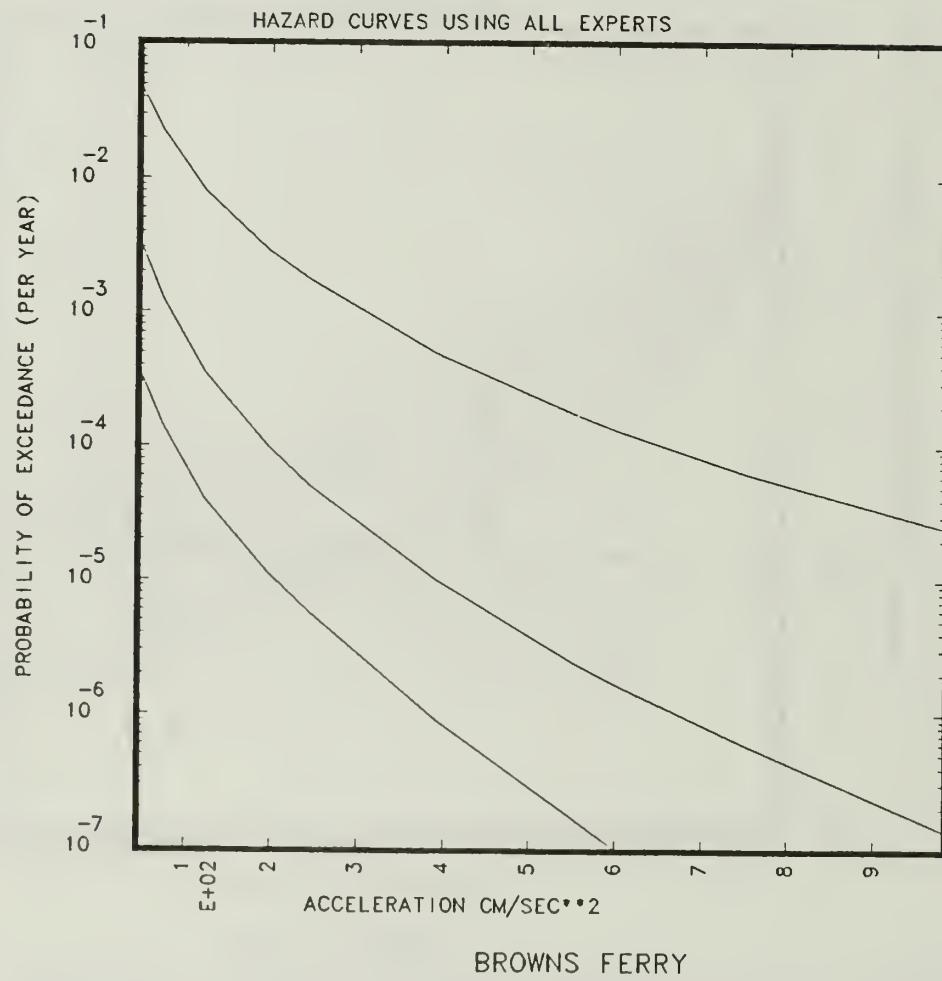


Figure 2.2.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Browns Ferry site.

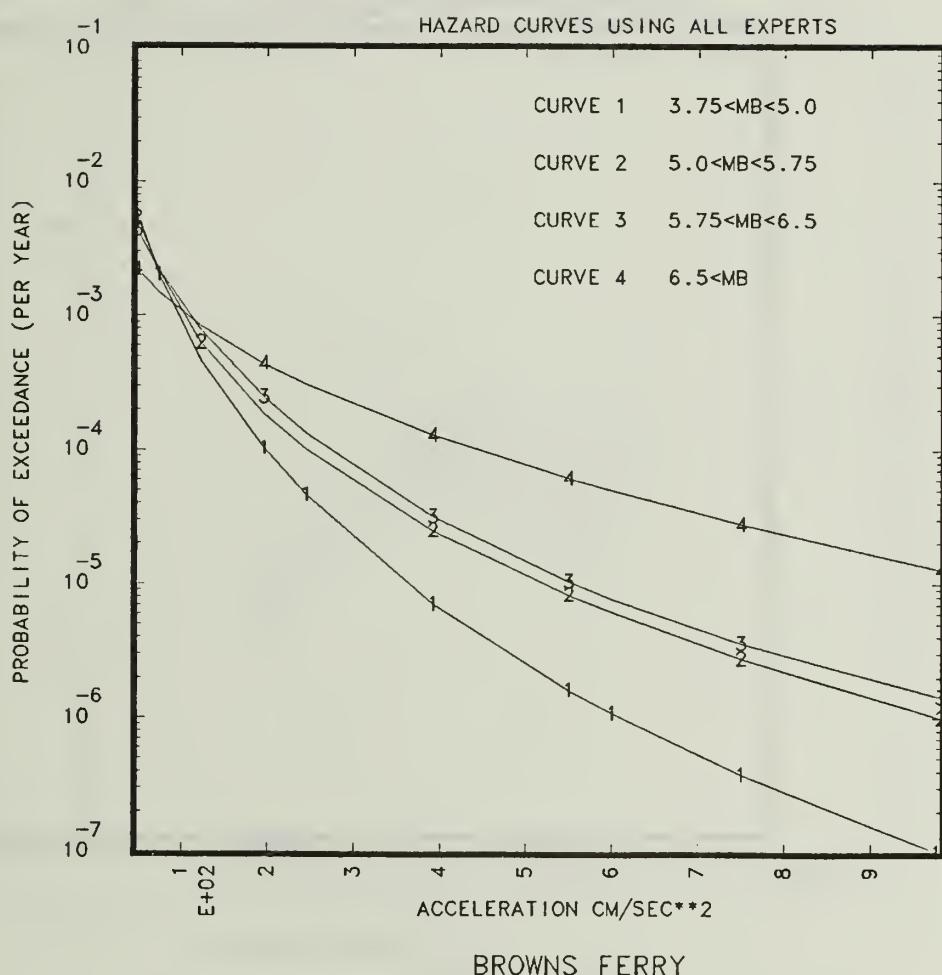


Figure 2.2.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Browns Ferry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

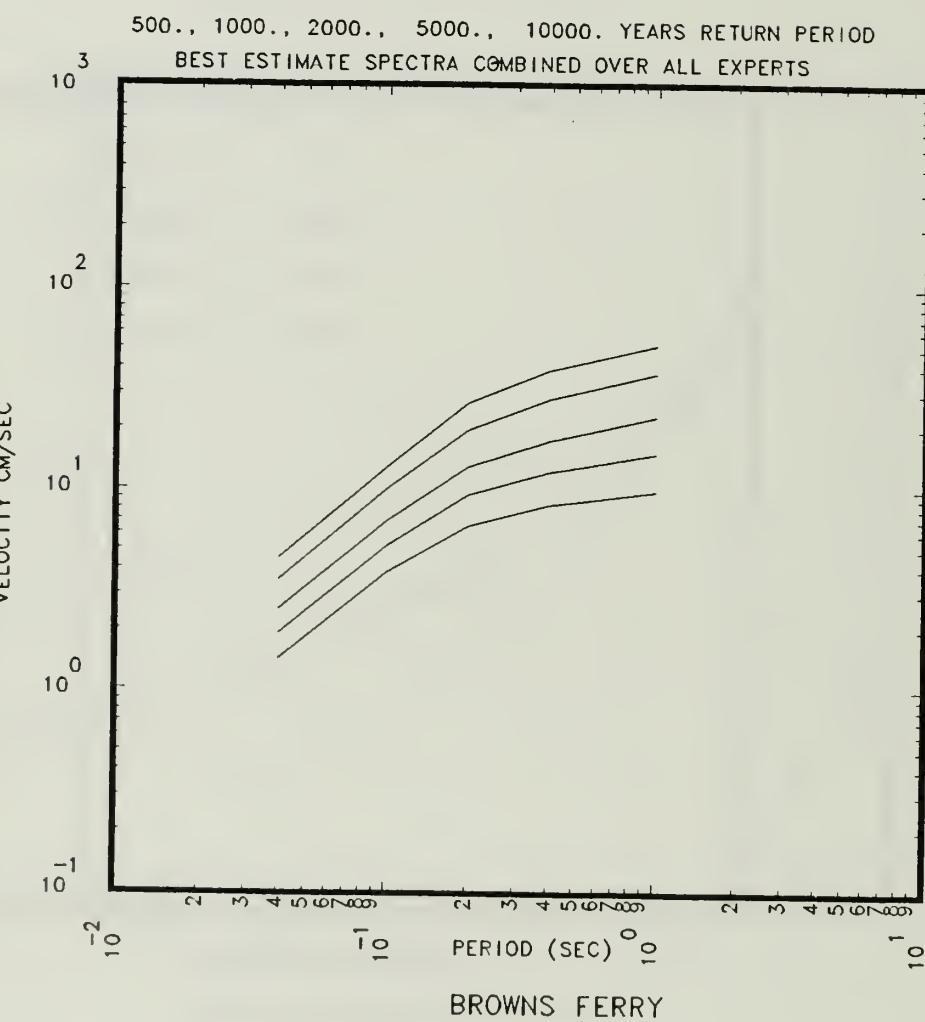


Figure 2.2.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Browns Ferry site.

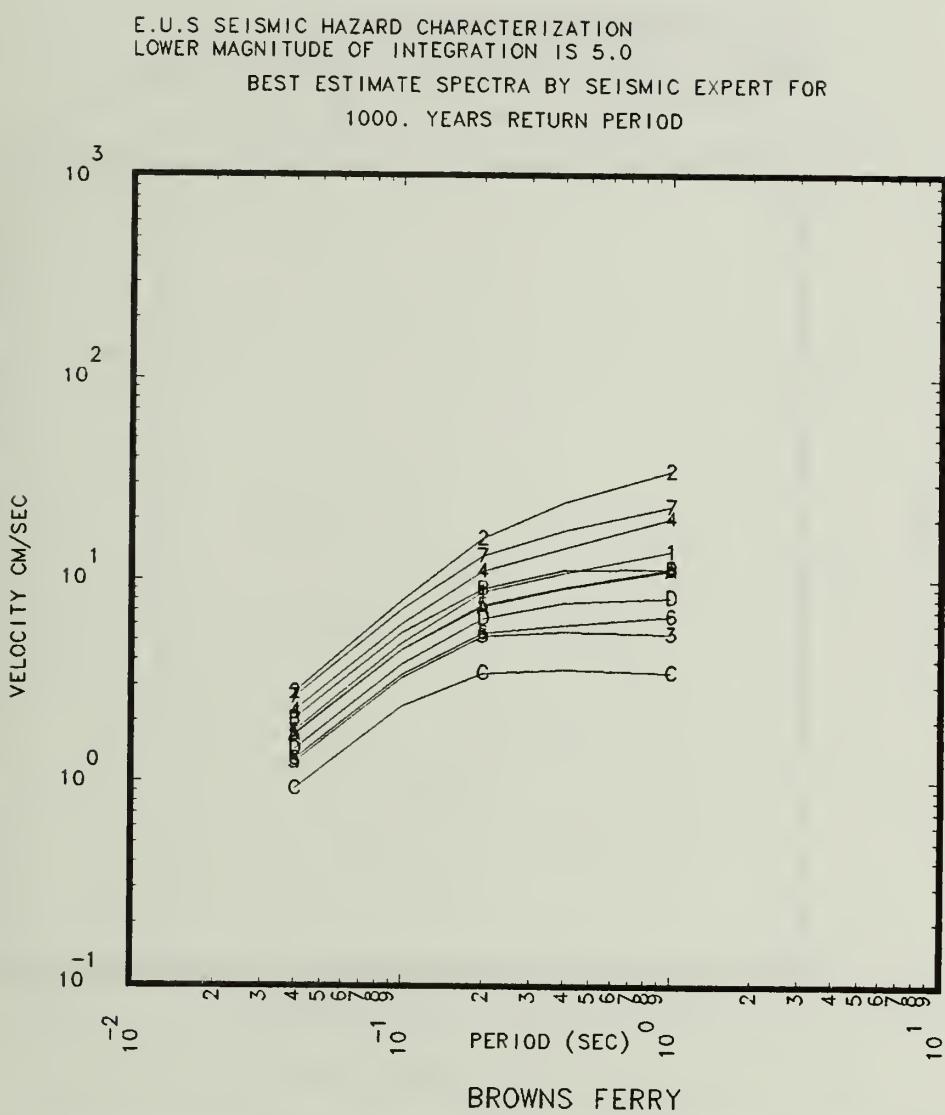


Figure 2.2.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Browns Ferry site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

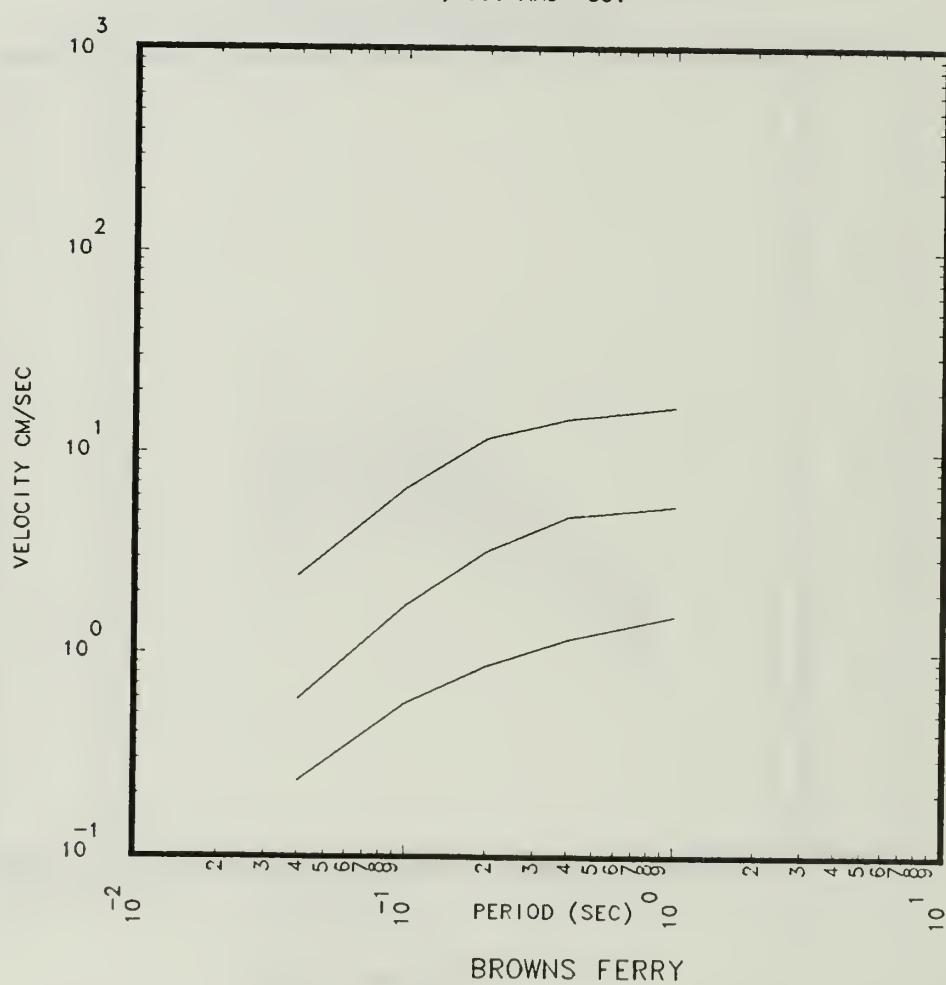


Figure 2.2.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Browns Ferry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

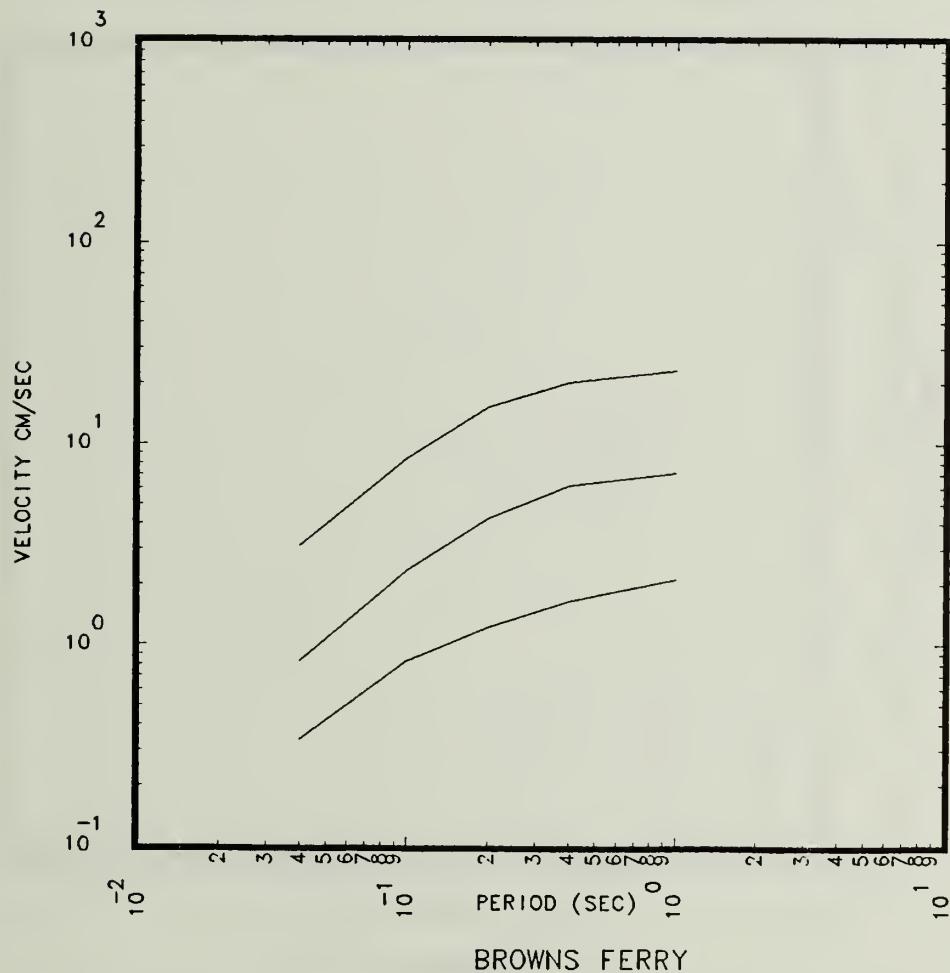


Figure 2.2.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Browns Ferry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

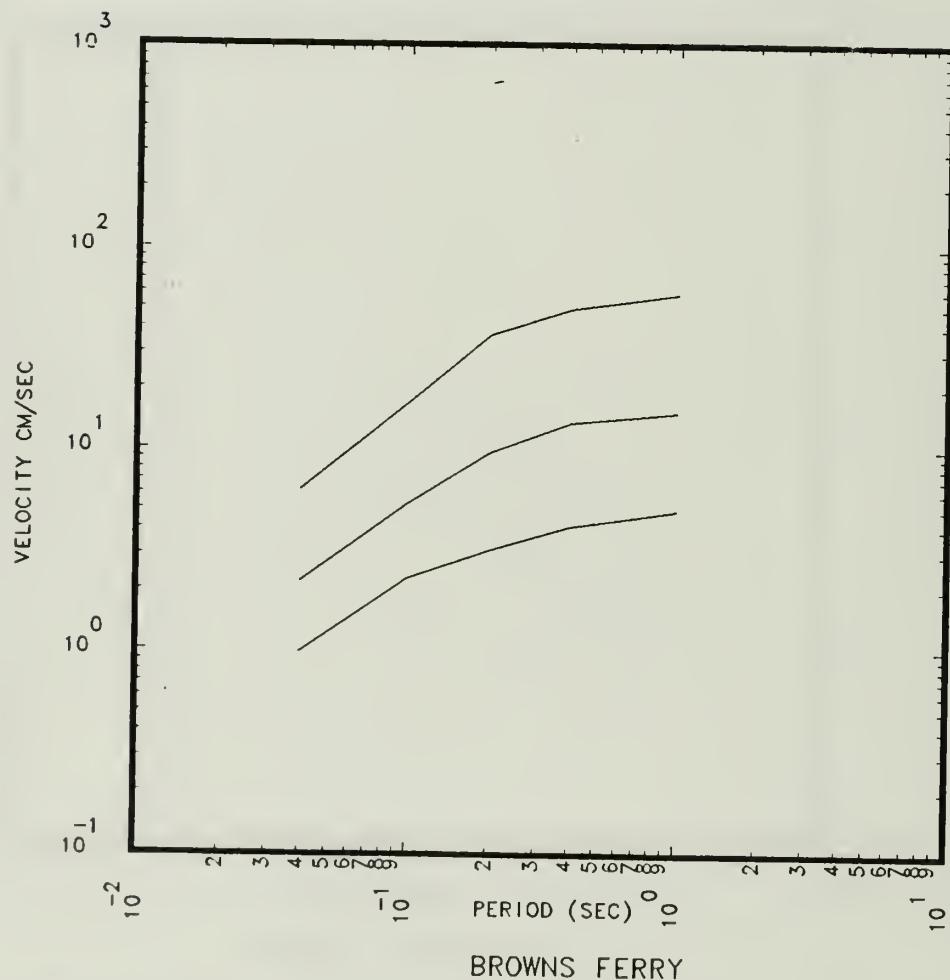


Figure 2.2.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Browns Ferry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

50-TH PERCENTILE SPECTRA FOR ALL RETURN PERIODS

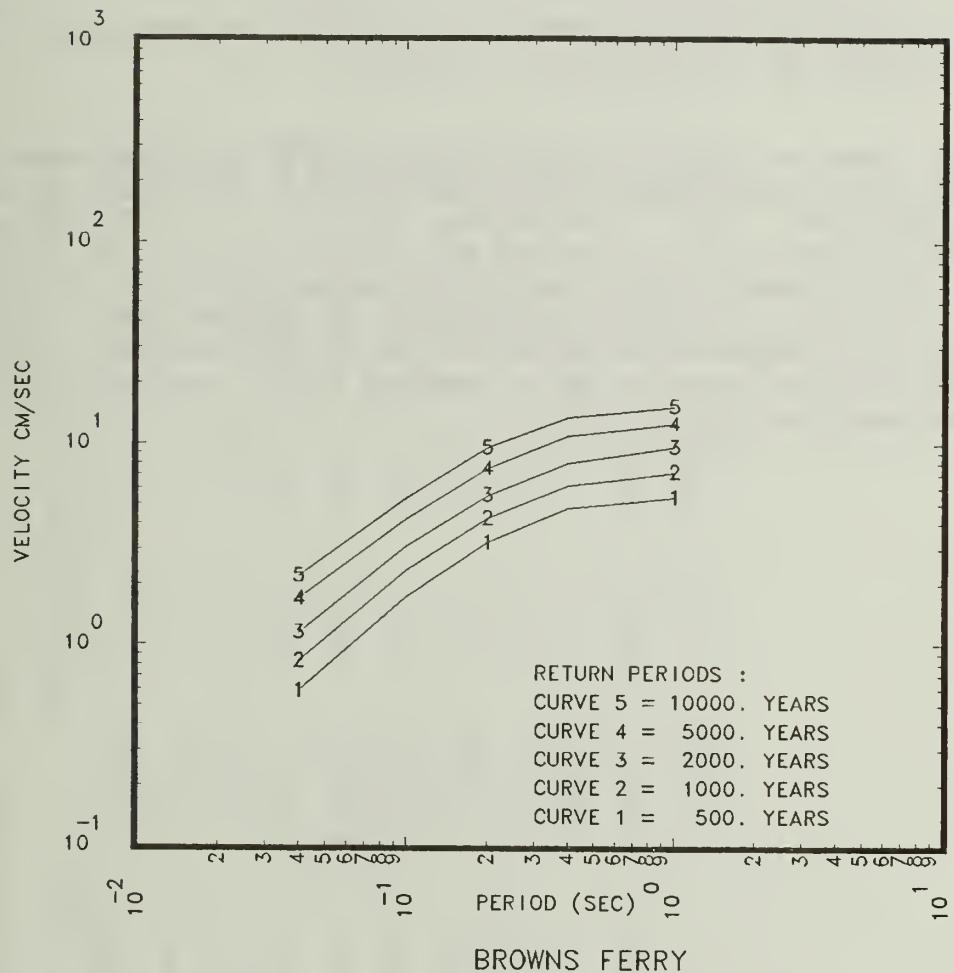


Figure 2.2.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Browns Ferry site.

2.3 BRUNSWICK

Brunswick was placed in the sand-1 (see Table 1.4) category. It is located in region 2 (southeast) and is represented by the symbol "3" on the location map (Fig. 1.1). This site is located within a relatively short distance of the zones representing the Charleston zone as modeled by most S-Experts. The Charleston zone plays an important role for most experts (i.e. S-Experts 1,2,3,4,5,6,7), where it dominates the hazard. For the other S-Experts (10,12,13) a bigger extended zone including the Charleston area, dominates the hazard.

Figure 2.3.1 shows typical results. The AMHC is slightly higher than the 85th percentile, (see Fig. 2.3.3).

Figure 2.3.2 indicates that the diversity of opinion, as measured by the spread of the BEHC for all S-Experts, is typical.

Figure 2.3.4 shows the relative contribution of earthquakes in several ranges of magnitude. Up to approximately 0.2g, the hazard is contributed equally from all 4 magnitude bins. Thus, if earthquakes in the 3.75 to 5.0 range were included, the hazard would be increased by about 30 percent. At the high g value end, the earthquakes in the lowest bin (magnitude 3.75 to 5) would not contribute significantly to the total hazard. As expected, due to the strong dominance of a high magnitude cutoff area, (the Charleston area), the strongest contribution over the entire range of PGA is from earthquakes greater than magnitude 6.5.

TABLE 2.3.1

MOST IMPORTANT ZONES PER S-EXPERT FOR BRUNSWICK

SITE SOIL CATEGORY **CATEGORY** **SAND-1**

S-XPT HOST ZONE NUMBER ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT 10% PGA (0.125G)

A1 HIGH (GARU.GUS/)		A2 HIGH (GARU.GUS/)		A3 HIGH (GARU.GUS/)	
1	ZONE 1 % CONT.:	ZONE 1 55.	ZONE 1 43.	ZONE 4 2.	ZONE 4 0.
2	COMP. ZO % CONT.:	ZONE 30 95.	COMP. ZON 4.	ZONE 27 0.	ZONE 30 94.
3	ZONE 8 % CONT.:	ZONE 9 43.	ZONE 8A 35.	COMP. ZON 17.	ZONE 8A 4.
4	COMP. ZO % CONT.:	ZONE 10 97.	COMP. ZON 1.	ZONE 8 0.	ZONE 8A 35.
5	ZONE 8 % CONT.:	ZONE 9 94.	ZONE 8 6.	ZONE 10 0.	ZONE 8A 9.
6	COMP. ZO % CONT.:	ZONE 13 88.	COMP. ZON 10.	ZONE 11 0.	ZONE 13 93.
7	ZONE 2 = % CONT.:	ZONE 10 92.	ZONE 2 8.	ZONE 8 0.	ZONE 9 7.
10	ZONE 4B % CONT.:	ZONE 4B 56.	ZONE 15 39.	ZONE 19 5.	ZONE 15 86.
11	ZONE 8 % CONT.:	ZONE 8 89.	CZ = ZONE 11.	ZONE 5 0.	ZONE 10 86.
12	ZONE 23 % CONT.:	ZONE 23 47.	ZONE 23A 40.	ZONE 25 3.	ZONE 99. 1.
13	CZ 17 % CONT.:	ZONE 9 35.	CZ 18 1.	ZONE 8 0.	CZ 17 11.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

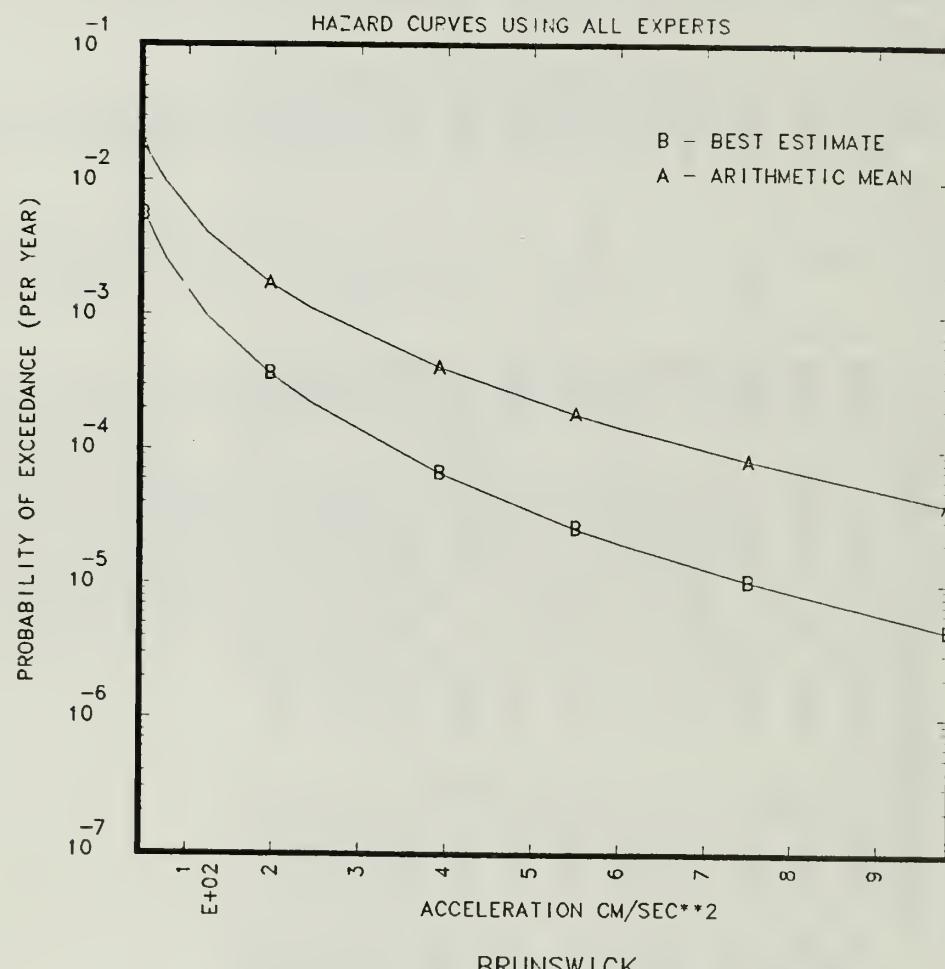


Figure 2.3.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Brunswick site.

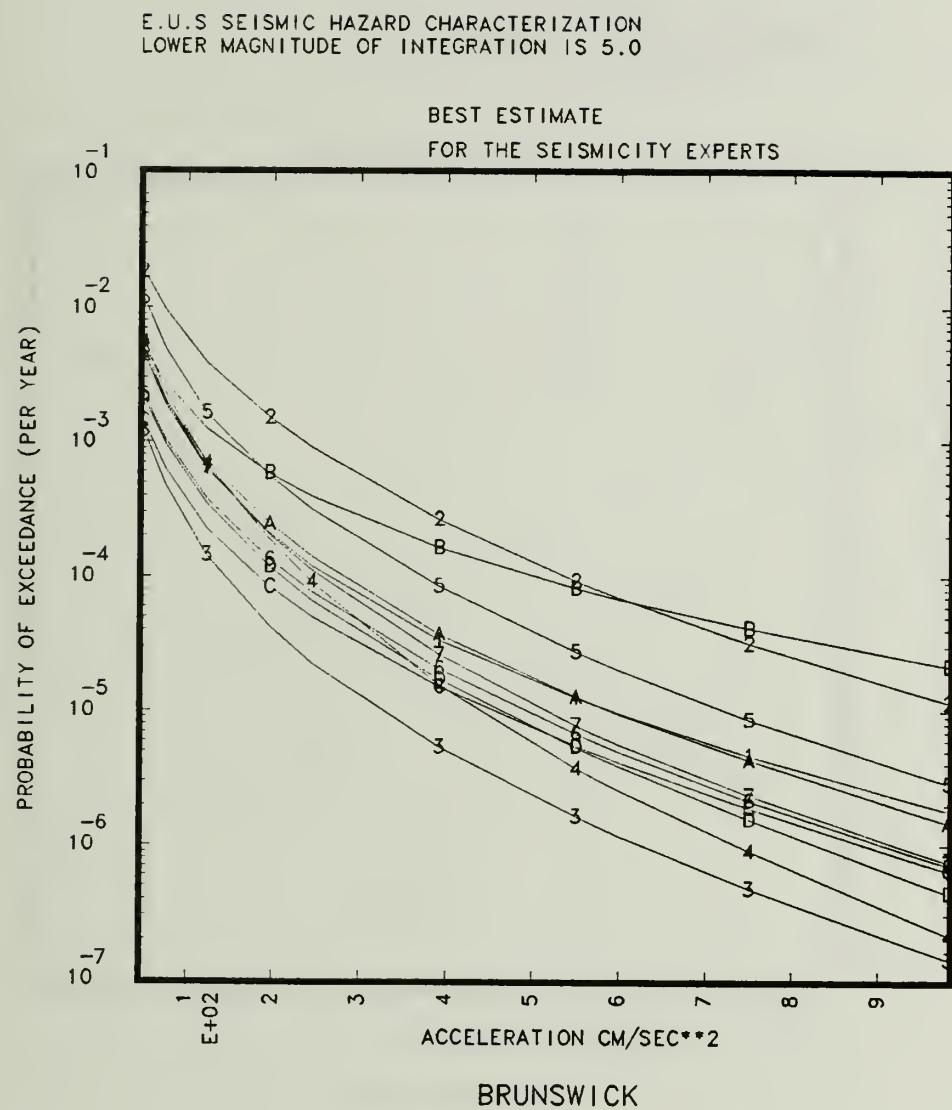


Figure 2.3.2 BEHCs per S-Expert combined over all G-Experts for the Brunswick site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

PERCENTILES = 15., 50. AND 85.

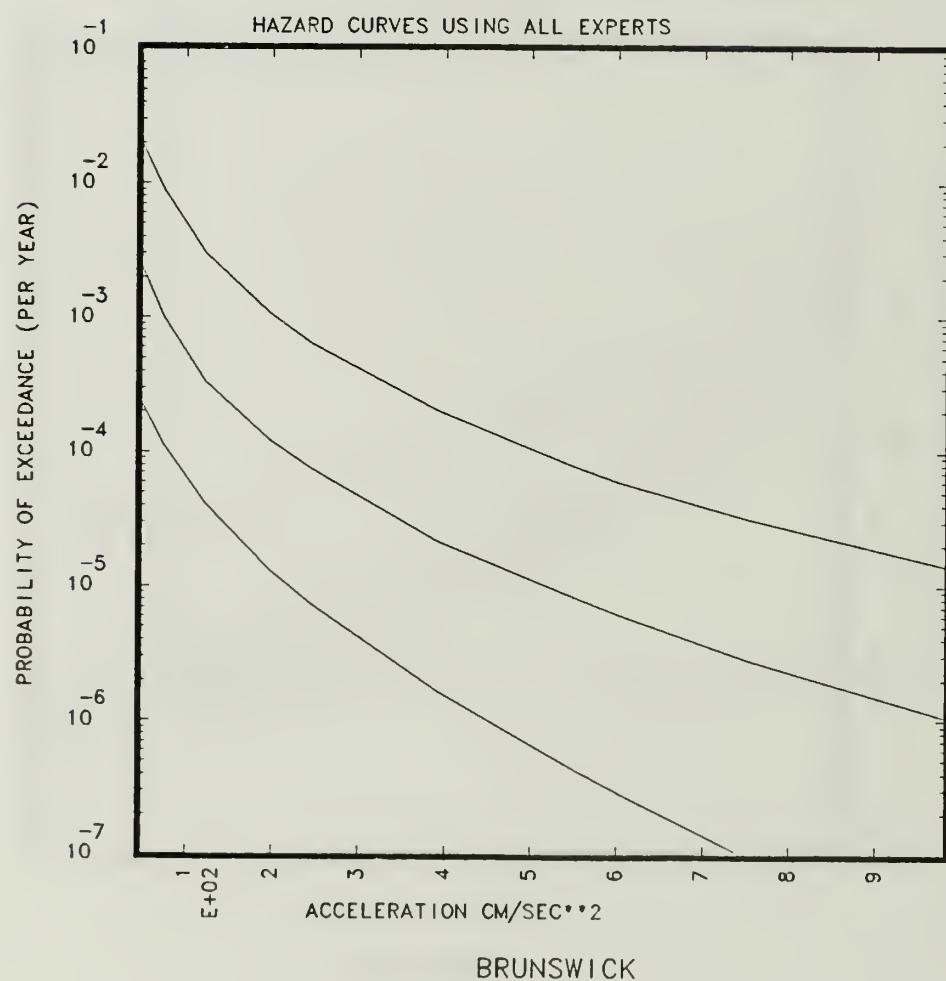


Figure 2.3.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Brunswick site.

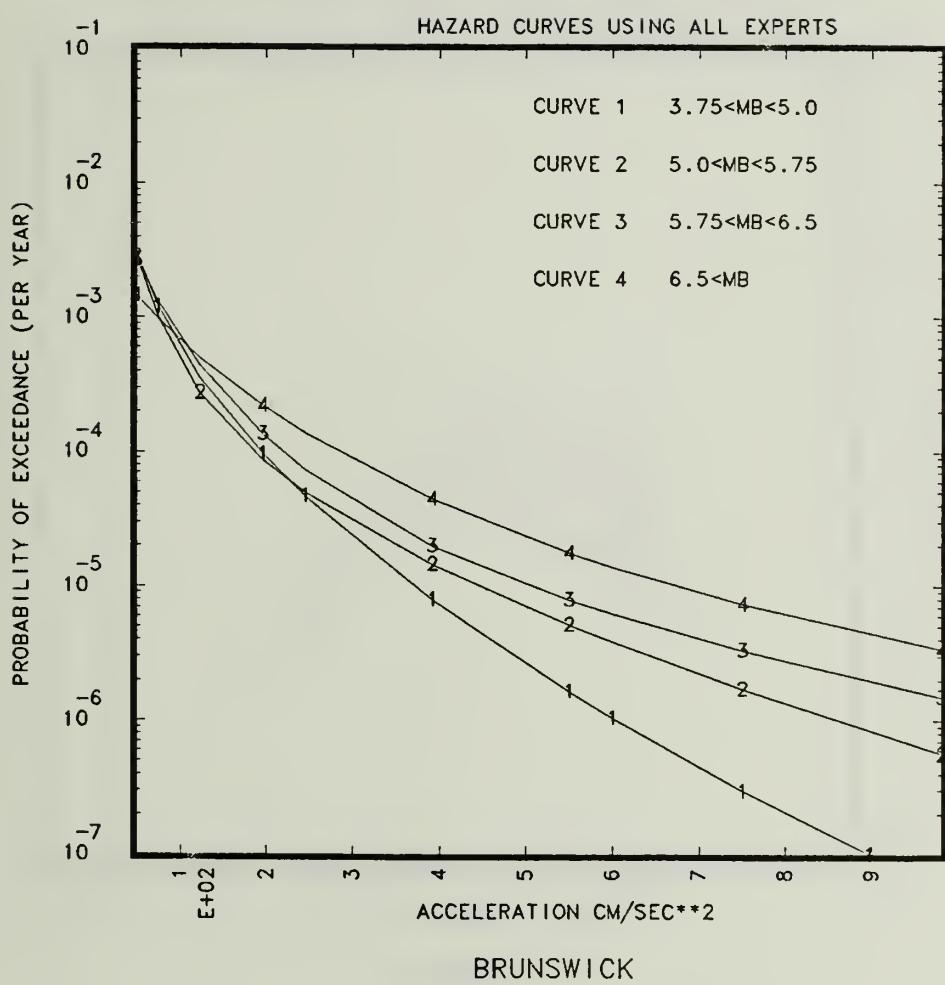


Figure 2.3.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Brunswick site.

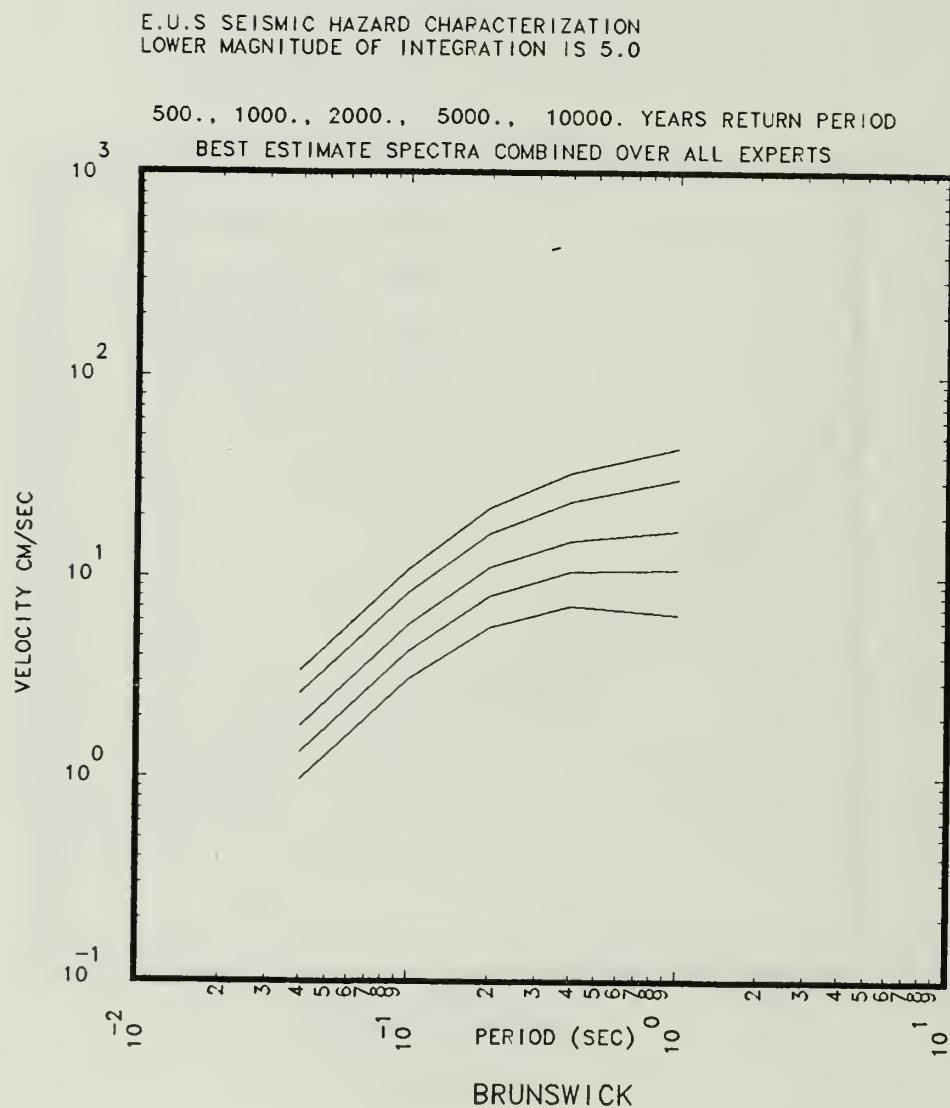


Figure 2.3.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Brunswick site.

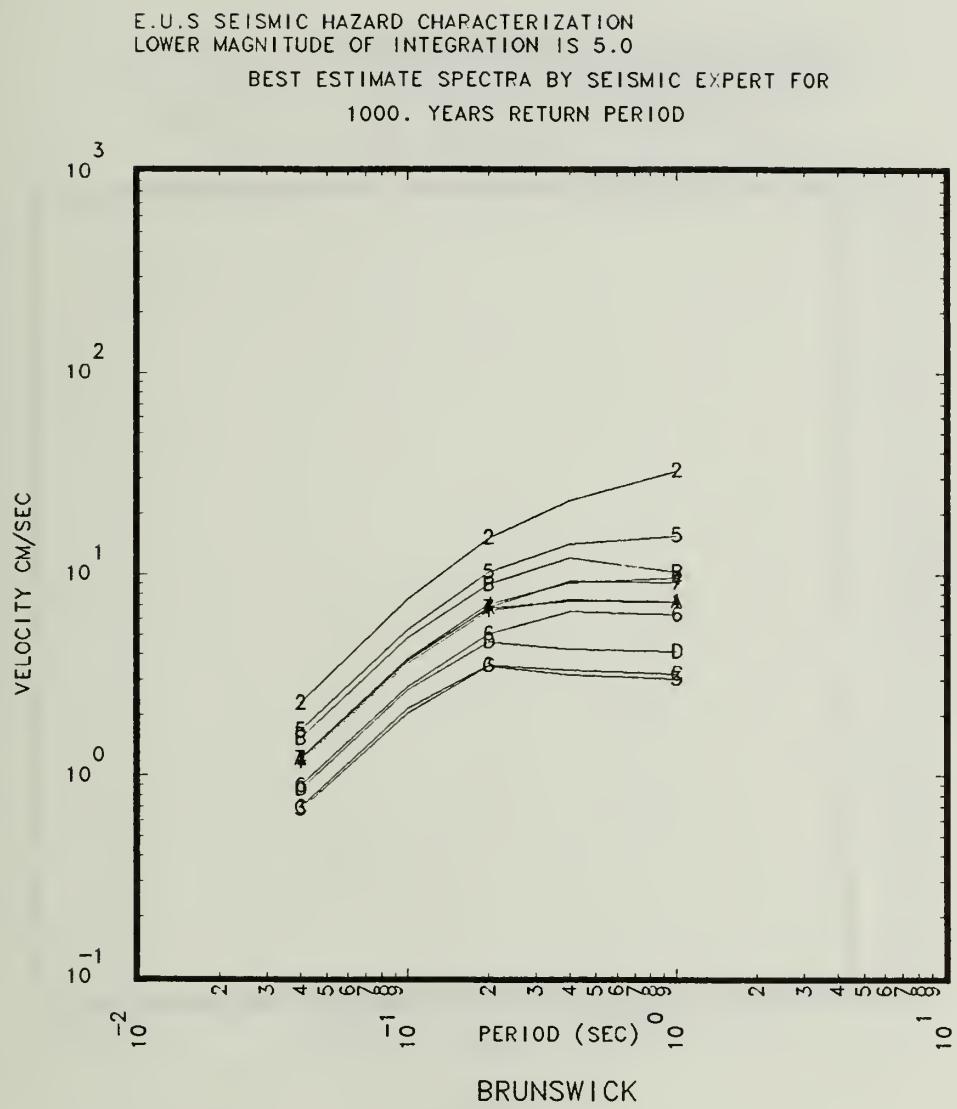


Figure 2.3.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Brunswick site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

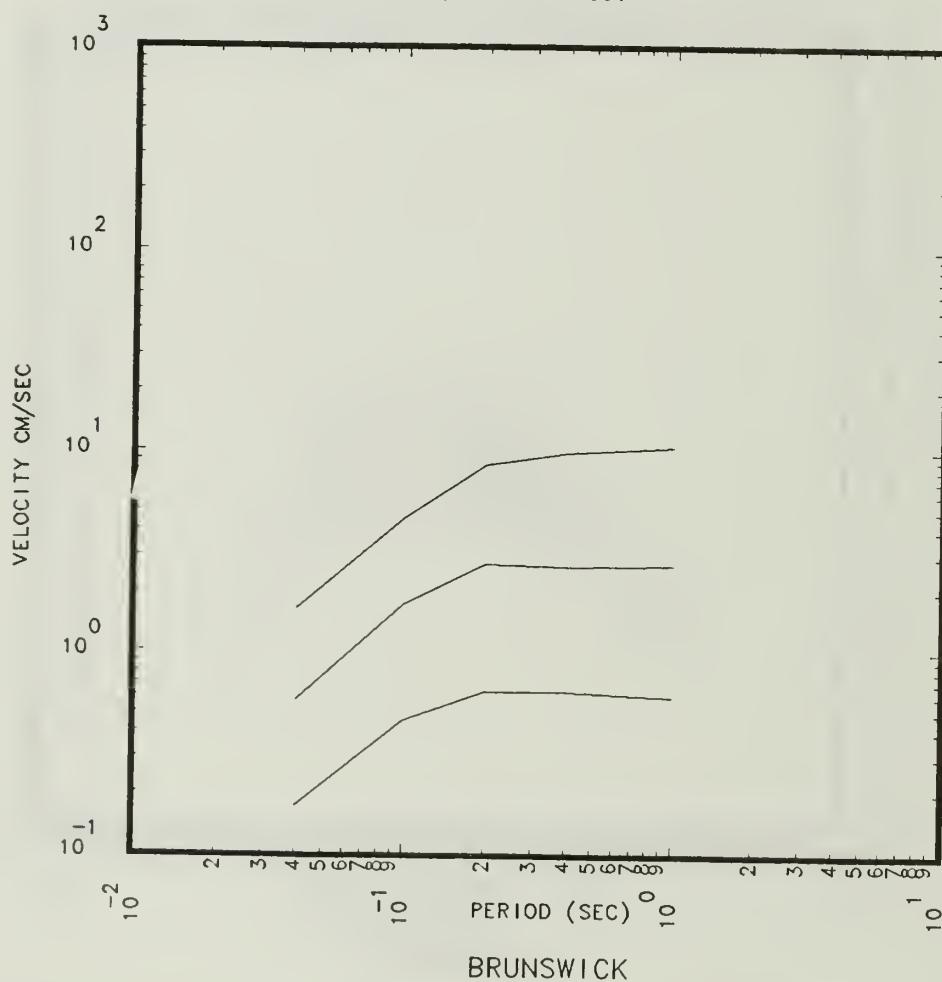


Figure 2.3.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Brunswick site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

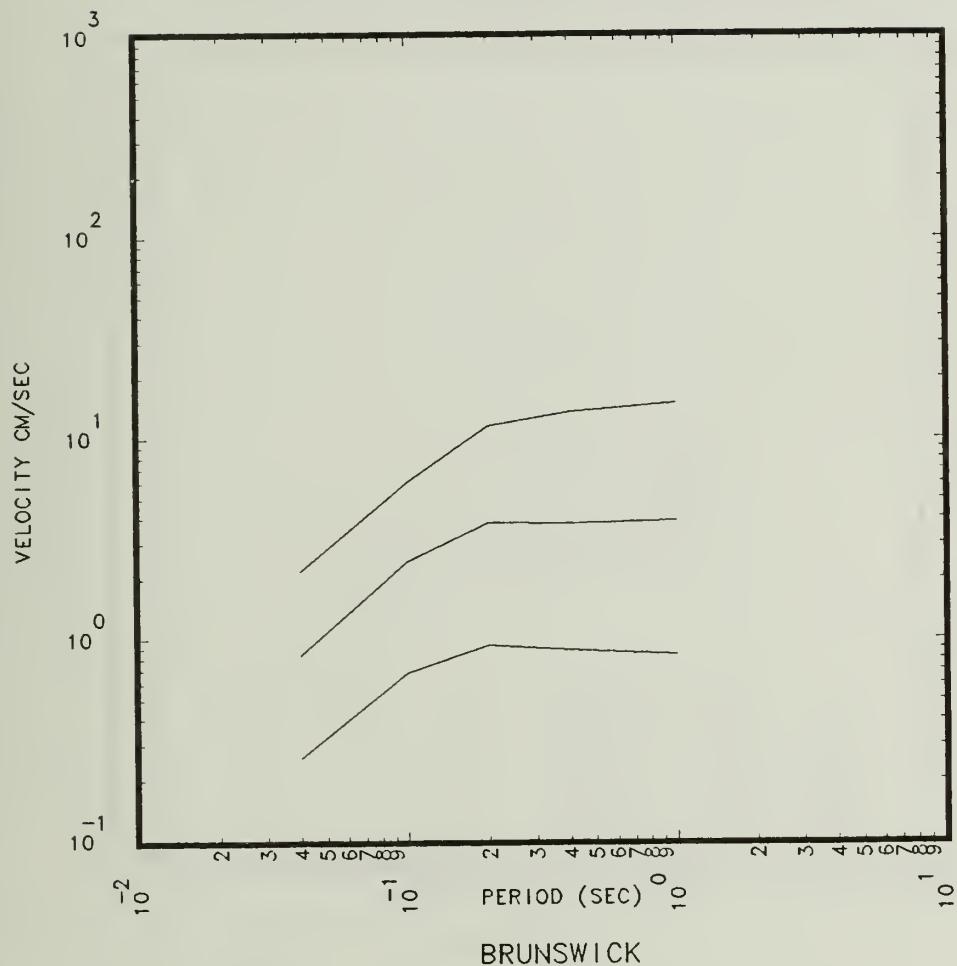


Figure 2.3.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Brunswick site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

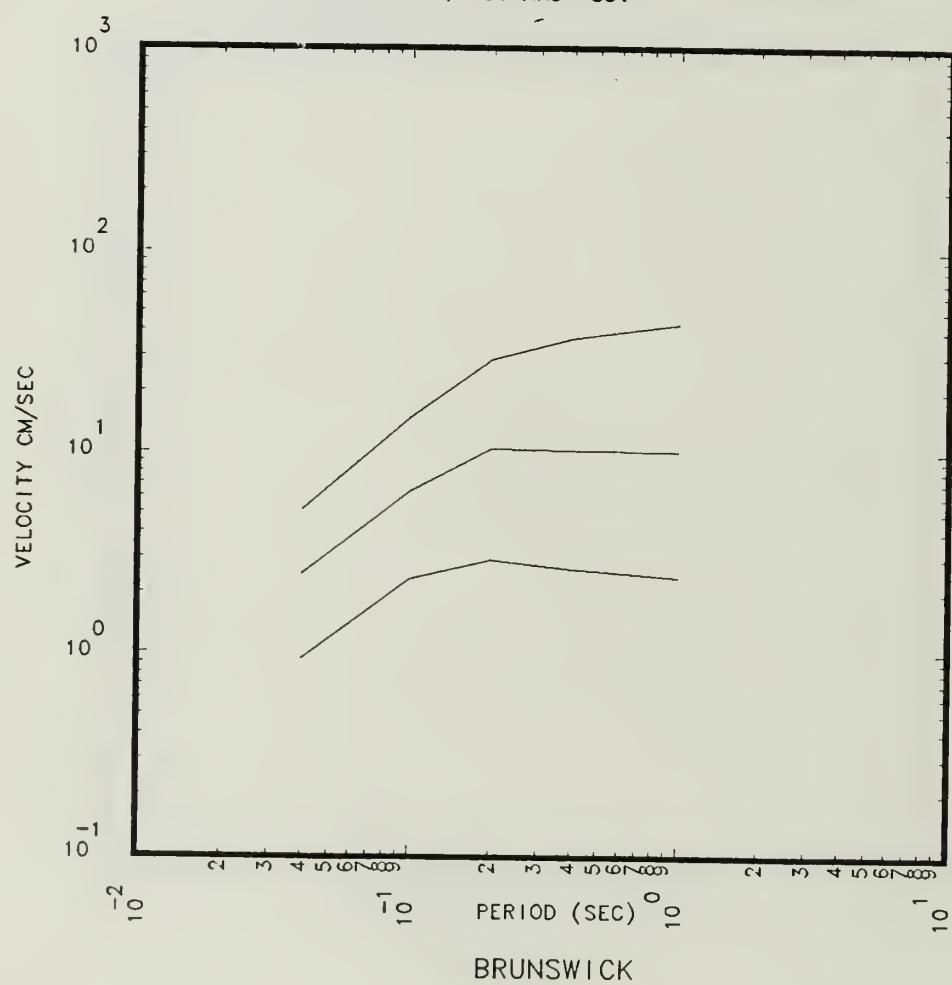


Figure 2.3.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Brunswick site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

50-TH PERCENTILE SPECTRA FOR ALL RETURN PERIODS

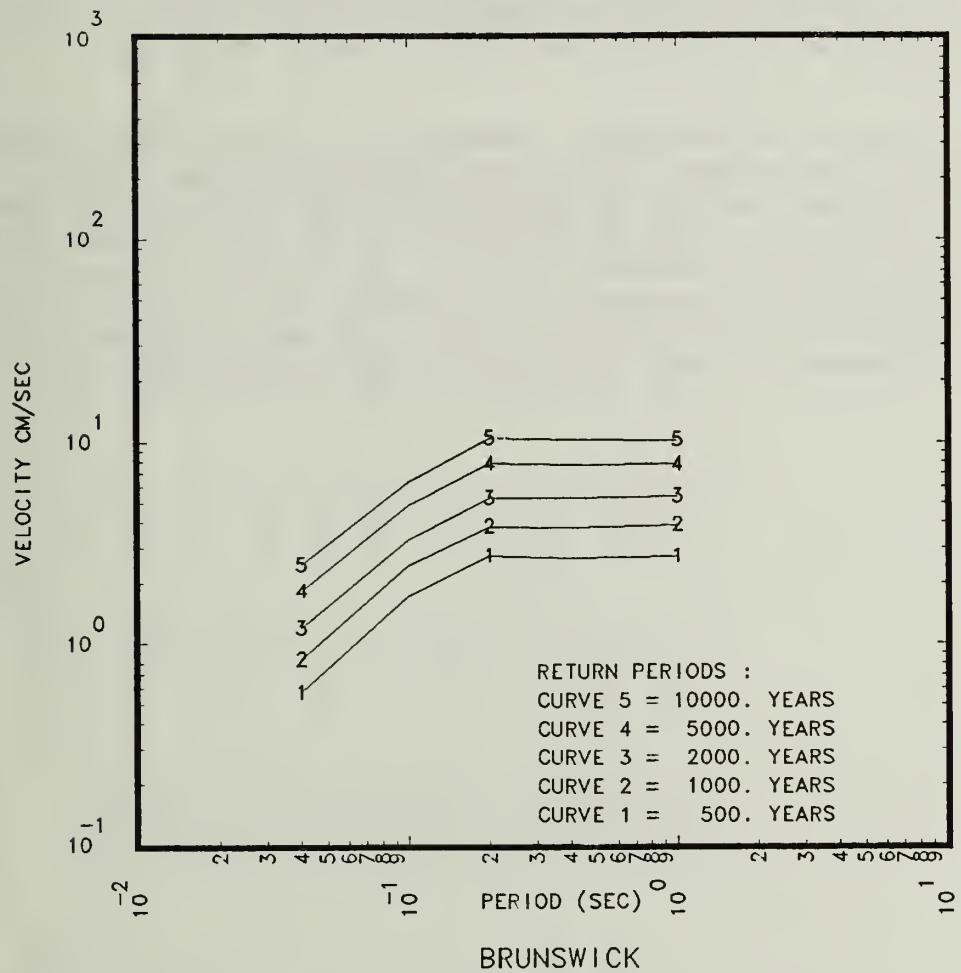


Figure 2.3.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Brunswick site.

2.4 CALVERT CLIFFS

Calvert Cliffs is a deep soil site and is represented by the symbol "4" in Fig. 1.1. Table 2.4.1 and Figs. 2.4.1 to 2.4.10 give the basic results for the Calvert Cliffs site. Because Calvert Cliffs is a deep soil site, the G-Expert 5's GM model does not dominate the BEHC as it does in the case of the rock site (See Section 2.1). A typical case showing the relatively small spread between the G-experts' BEHC for a given S-Expert's input is shown in Fig. 2.4.11. As a consequence the uncertainty in the hazard, for a given S-Expert is also relatively small.

Table 2.4.1 shows that for all S-Experts but expert 6, the dominant contribution at 0.6g comes from the host zone and the same is true for all but experts 6 and 4 at 0.125g. Thus, as expected, a discrimination of the hazard by distance bins would show the clear dominance of near site earthquakes (i.e. dominant contribution from earthquakes within 15 km of the site).

Similar discrimination of earthquake contribution by magnitude bins shows a clear dominance of earthquakes in the range between magnitude 5.0 and magnitude 6.5 with much smaller contribution from earthquake in the first bin (i.e. 3.75 to 5.00) at high PGA levels and one order of magnitude smaller contribution from large earthquakes ($m_b > 6.5$). By contrast, the small earthquakes (3.75 to 5.00) dominate for PGA smaller than 0.2g. Thus including the small earthquakes in the range up to PGA = 0.2g would increase the BEHC significantly, however, it would not affect the BEHC above about 0.3g.

TABLE 2.4.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR CALVERT CLIFFS

SITE SOIL CATEGORY DEEP-SOIL

S-XPT HOST
NUM. ZONE

		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT HIGH PGA(0.60G)									
		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC(0.125G)									
1	ZONE 1	ZONE ID: ZONE 1 % CONT.: 81.	ZONE 4 9.	ZONE 3 7.	ZONE 2 1.	ZONE 1 99.	ZONE 3 1.	ZONE 4 0.	ZONE 2 0.	ZONE 4 0.	ZONE 2 0.
2	ZONE 28	ZONE ID: ZONE 28 % CONT.: 88.	ZONE 27 6.	ZONE 30 4.	ZONE 30 1.	ZONE 28 98.	ZONE 28 1.	ZONE 27 1.	ZONE 27 1.	ZONE 27 1.	ZONE 30 0.
3	ZONE 8A	ZONE ID: ZONE 8A % CONT.: 82.	ZONE 5 13.	ZONE 6 5.	ZONE 9 0.	ZONE 9 99.	ZONE 5 1.	ZONE 6 0.	ZONE 6 0.	ZONE 6 0.	ZONE 30 0.
4	COMP. Z0	ZONE ID: ZONE 8 % CONT.: 35.	ZONE 10 22.	COMP. Z0 18.	ZONE 11 11.	COMP. Z0 11.	COMP. Z0 89.	ZONE 8 11.	ZONE 8 0.	ZONE 7 0.	ZONE 26 0.
5	ZONE 8	ZONE ID: ZONE 8 % CONT.: 54.	ZONE 1 22.	ZONE 9 21.	ZONE 6 2.	ZONE 8 79.	ZONE 8 19.	ZONE 1 2.	ZONE 9 2.	ZONE 9 0.	ZONE 26 0.
6	COMP. Z0	ZONE ID: ZONE 6 % CONT.: 79.	ZONE 15 10.	COMP. Z0 6.	ZONE 13 4.	ZONE 6 90.	COMP. Z0 9.	ZONE 15 1.	ZONE 15 1.	ZONE 15 1.	ZONE 13 0.
7	ZONE 29	ZONE ID: ZONE 29 % CONT.: 88.	ZONE 7 7.	ZONE 9 3.	ZONE 10 1.	ZONE 29 99.	ZONE 7 1.	ZONE 2 0.	ZONE 2 0.	ZONE 2 0.	ZONE 9 0.
10	ZONE 4B	ZONE ID: ZONE 4B % CONT.: 97.	ZONE 19 1.	ZONE 1 1.	ZONE 15 0.	ZONE 19 97.	ZONE 19 3.	ZONE 1 0.	ZONE 1 0.	ZONE 1 0.	ZONE 2 0.
11	CZ = ZON	ZONE ID: CZ = ZONE ZONE 5 % CONT.: 65.	ZONE 8 22.	ZONE 7 10.	ZONE 7 1.	CZ = ZONE ZONE 8 90.	ZONE 8 6.	ZONE 5 3.	ZONE 5 3.	ZONE 6 0.	ZONE 6 0.
12	ZONE 32	ZONE ID: ZONE 32 % CONT.: 99.	ZONE 23A 0.	ZONE 20 0.	ZONE 31 0.	ZONE 32 100.	ZONE 17 0.	ZONE 18 0.	ZONE 18 0.	ZONE 19 0.	ZONE 19 0.
13	CZ 17	ZONE ID: CZ 17 % CONT.: 97.	CZ 15 2.	ZONE 9 1.	ZONE 8 0.	CZ 17 96.	CZ 15 4.	ZONE 7 0.	ZONE 7 0.	ZONE 8 0.	ZONE 8 0.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

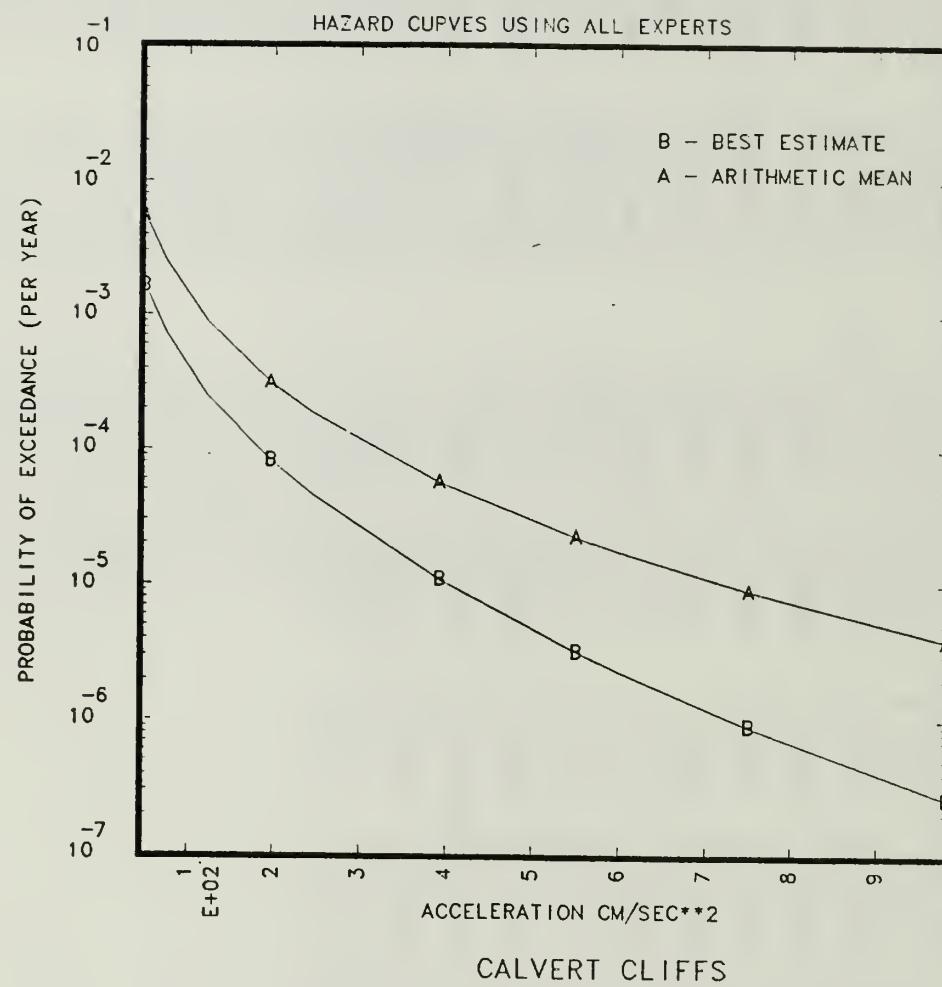


Figure 2.4.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Calvert Cliffs site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

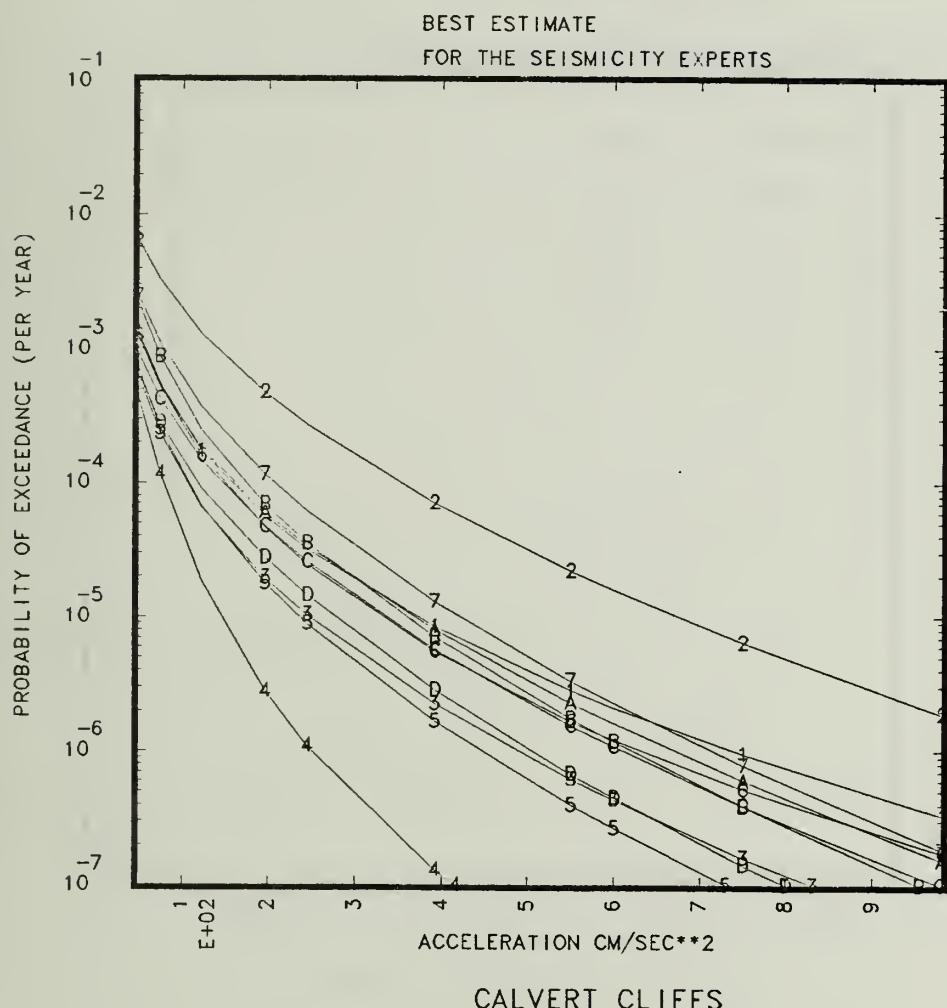


Figure 2.4.2 BEHCs per S-Expert combined over all G-Experts for the Calvert Cliffs site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

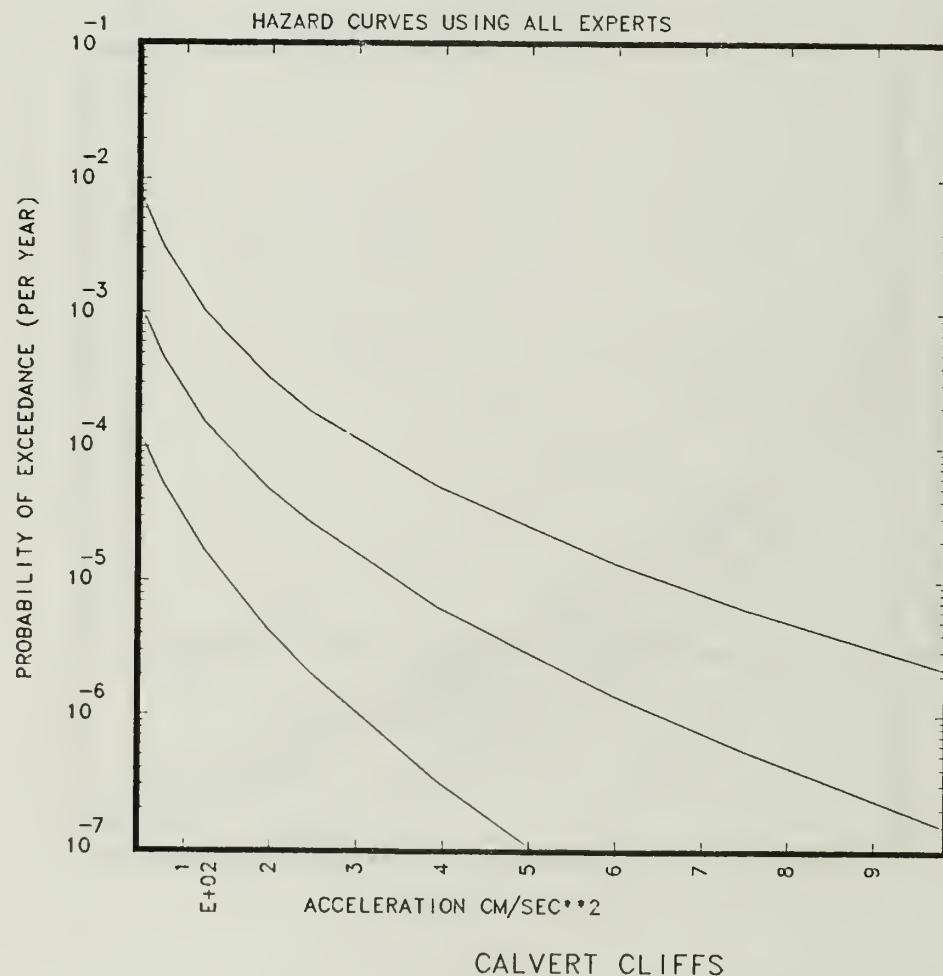


Figure 2.4.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Calvert Cliffs site.

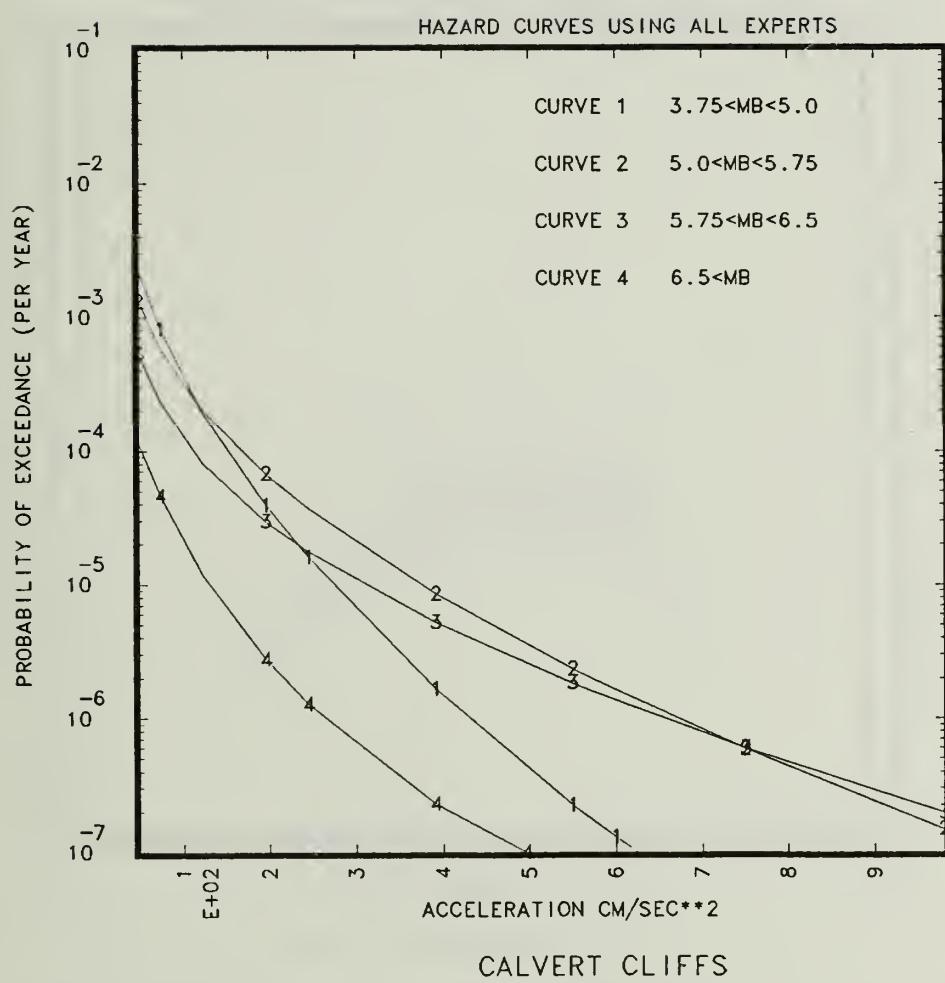


Figure 2.4.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Calvert Cliffs site.

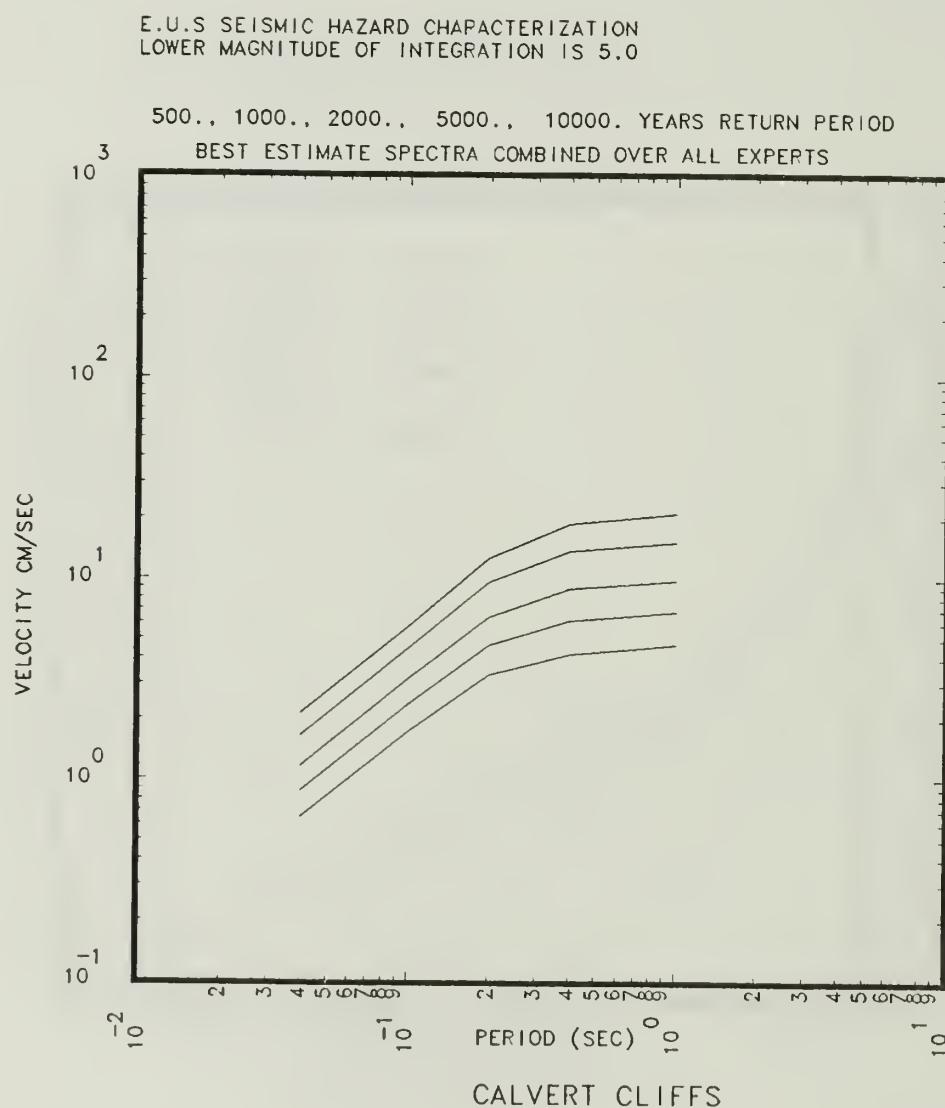


Figure 2.4.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Calvert Cliffs site.

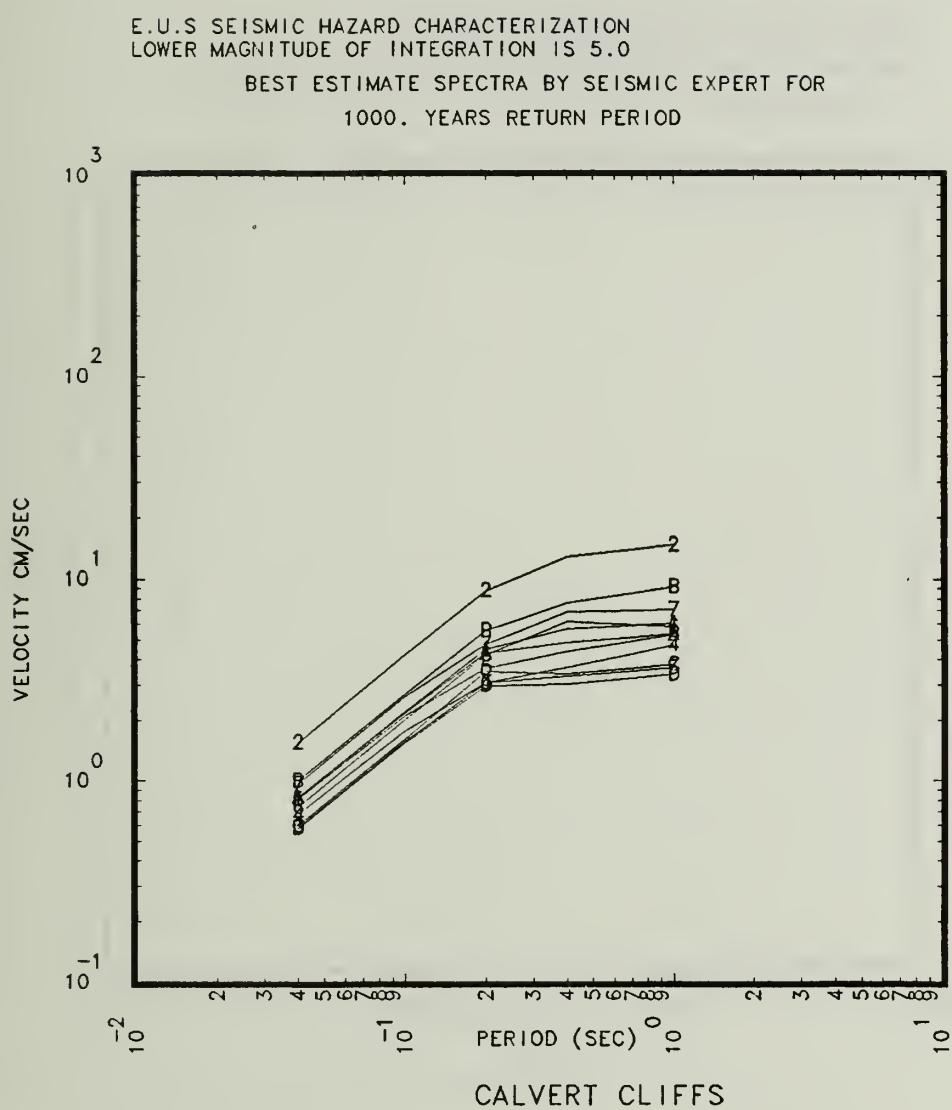


Figure 2.4.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Calvert Cliffs site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

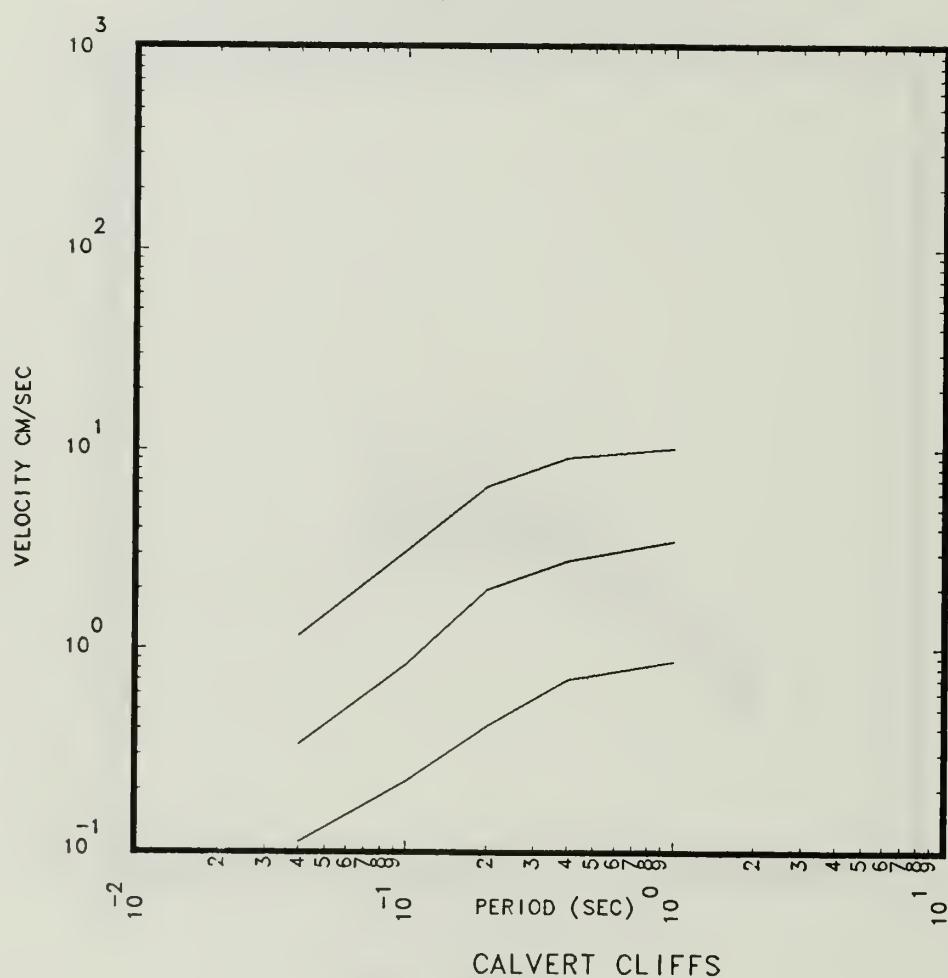


Figure 2.4.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Calvert Cliffs site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

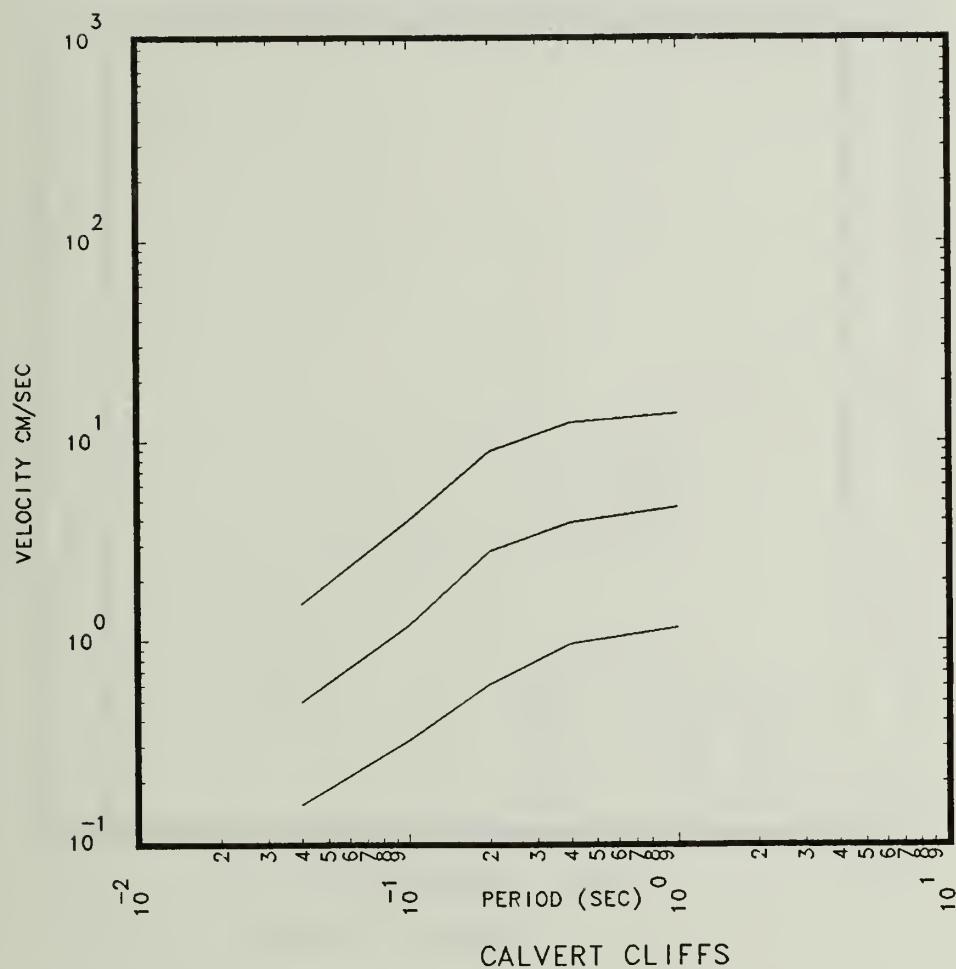


Figure 2.4.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Calvert Cliffs site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

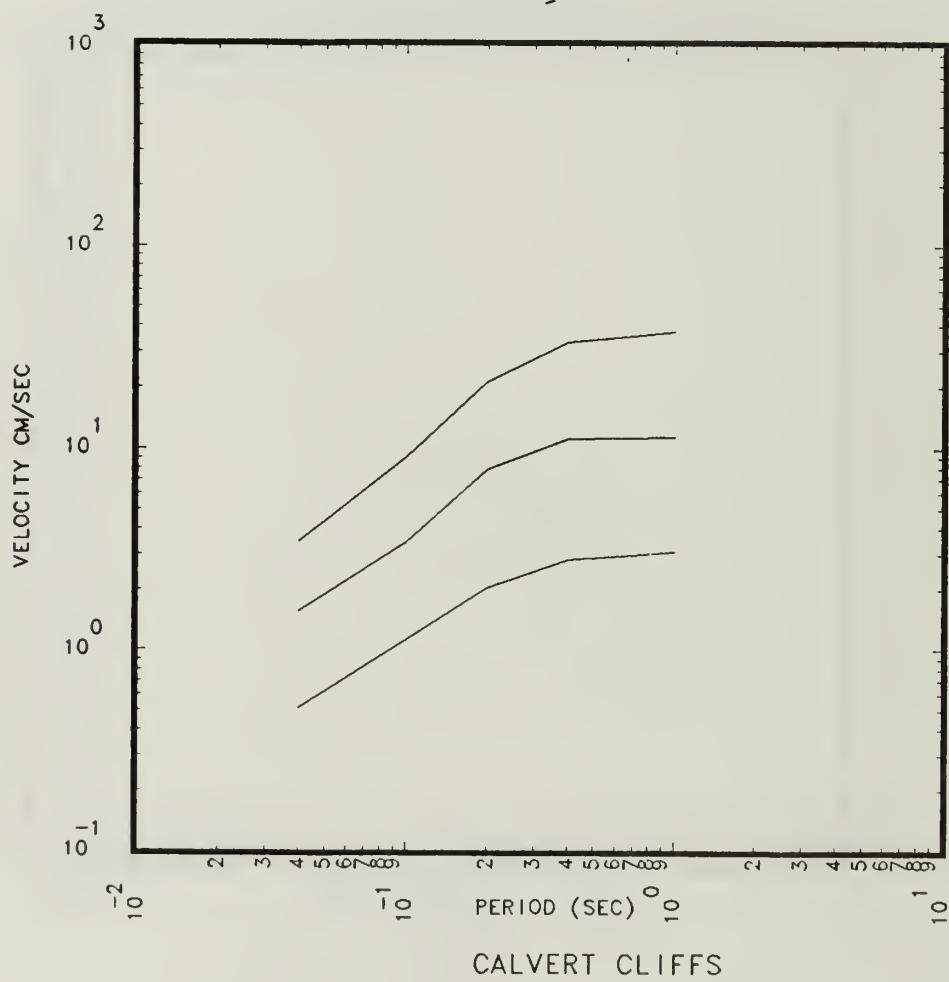


Figure 2.4.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Calvert Cliffs site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

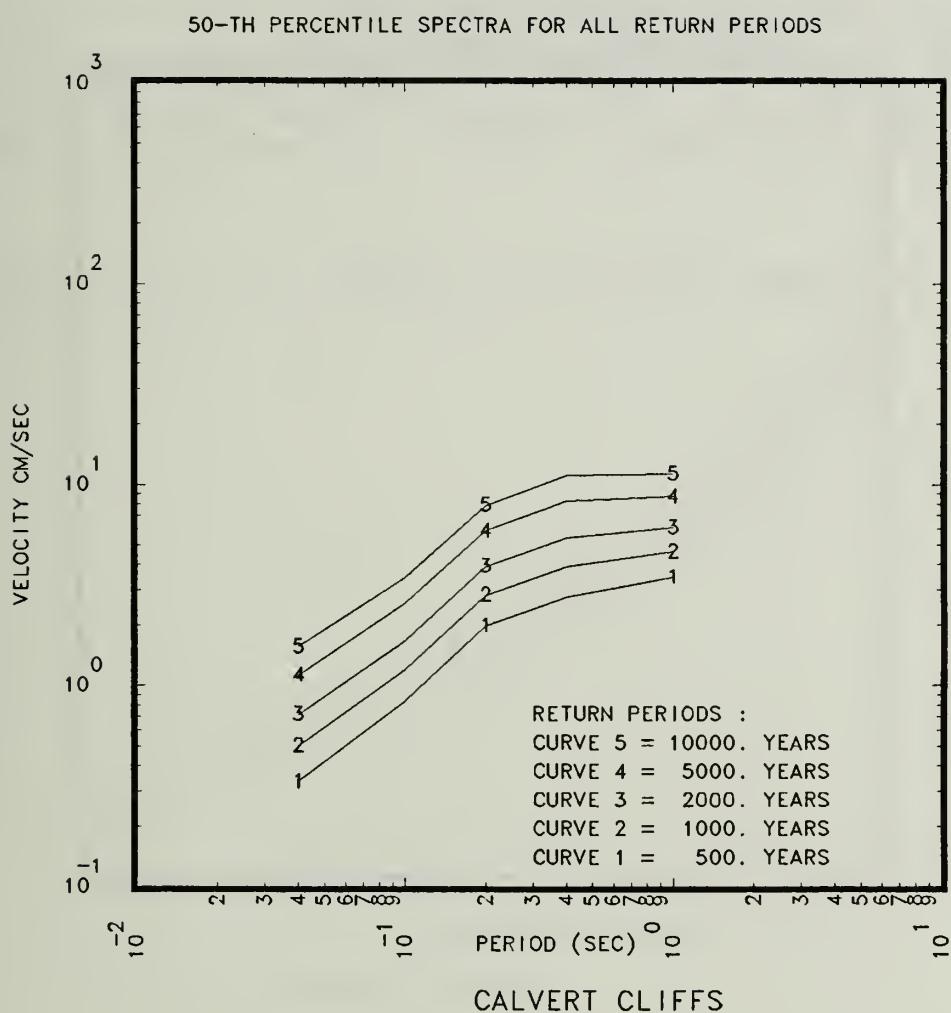


Figure 2.4.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Calvert Cliffs site.

EUS SEISMIC HAZARD CHARACTERIZATION,
LOWER MAGNITUDE OF INTEGRATION = 5.

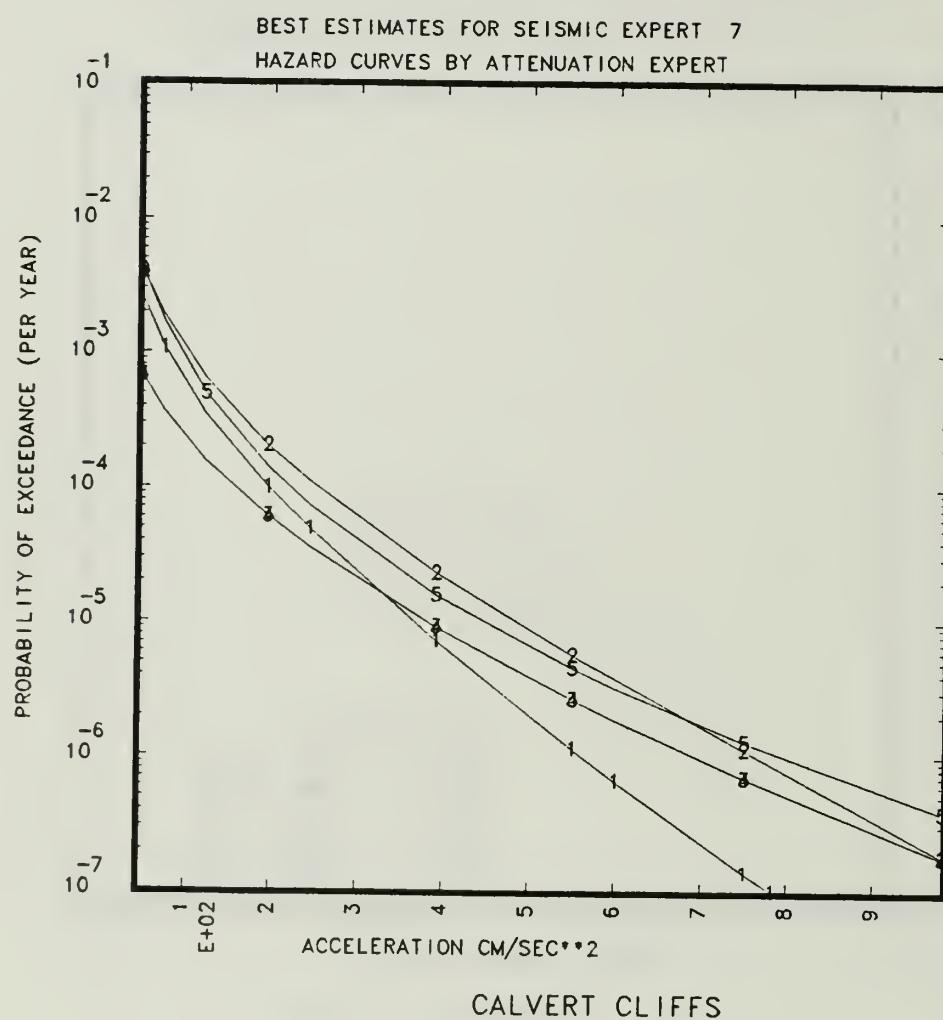


Figure 2.4.11 Comparison of the BEHCs for PGA for G-Expert for S-Expert 7's input for the Calvert cliffs site. The spread between these curves is typical of the spread for deep soil sites in region 2 (South east).

2.5 CATAWBA

Catawba is a rock site and is represented by the symbol "5" in Fig. 1.1. Table 2.5.1 and Figs. 2.5.1 to 2.5.10 give the basic results for the Catawba site.

Table 2.5.1 shows that the Charleston area has a significant effect on the hazard at Catawba. In particular, for S-Experts 2,4,5,6,7, and 12 the dominant zones are the smaller areas limited to the Charleston vicinity, which have a relatively high upper magnitude (or intensity) cutoff.

Figure 2.5.4 shows that the large earthquakes (greater than magnitude 6.5) contribute the most to the hazard for all PGA values greater than 0.1g. Below that PGA value, the small earthquakes (less than magnitude 5) would contribute the most, thus if their contribution were added to the results in Figs. 2.5.1 and 2.5.3, the hazard would be increased up to a factor of approximately 50% for PGA values less than 0.1g. The AMHC is higher than the 85th percentile CPHC.

In addition to the above comments, all the typical comments for rock site (see Section 2.1) apply also for this site.

TABLE 2 51

MOST IMPORTANT ZONES PER S-EXPERT FOR CATAWBA

SITE	SOIL	CATEGORY	ROCK	S-XPT NUM.	HOST ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G) % CON ₁	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT HIGH PGA(0.60G) % CON ₂	
1	ZONE 3	ZONE ID: ZONE 3 % CON ₁ :	ZONE 2 11.	ZONE 9 ZONE 4 ZONE 6.	ZONE 78. ZONE 14.	ZONE 3 ZONE 2 ZONE 14.	ZONE 9 ZONE 6.	
2	ZONE 29	ZONE ID: ZONE 30 % CON ₁ :	ZONE 29 ZONE 26. 52.	ZONE 18 ZONE 27 ZONE 8.	ZONE 30 ZONE 63.	ZONE 29 ZONE 27.	ZONE 18 ZONE 6.	
3	ZONE 7	ZONE ID: ZONE 7 % CON ₁ :	ZONE 9 54.	ZONE 5 ZONE 13 ZONE 2.	ZONE 7 ZONE 81.	ZONE 9 ZONE 15.	ZONE 5 ZONE 3.	
4	ZONE 9	ZONE ID: ZONE 10 % CON ₁ :	ZONE 9 48.	ZONE 4 ZONE 33. ZONE 10.	ZONE 26 ZONE 2. <td>ZONE 9 ZONE 52.</td> <td>ZONE 10 ZONE 44.</td> <td>ZONE 11 ZONE 2.</td>	ZONE 9 ZONE 52.	ZONE 10 ZONE 44.	ZONE 11 ZONE 2.
5	ZONE 10	ZONE ID: ZONE 9 % CON ₁ :	ZONE 10 68.	ZONE 15 ZONE 7. <td>ZONE 11 ZONE 5.</td> <td>ZONE 9 ZONE 81.</td> <td>ZONE 10 ZONE 15.</td> <td>ZONE 11 ZONE 3.</td>	ZONE 11 ZONE 5.	ZONE 9 ZONE 81.	ZONE 10 ZONE 15.	ZONE 11 ZONE 3.
6	ZONE 13	ZONE ID: ZONE 13 % CON ₁ :	ZONE 11 83.	ZONE 17 ZONE 14. 1.	ZONE 18 ZONE 1. <td>ZONE 13 ZONE 96.</td> <td>ZONE 11 ZONE 4.</td> <td>ZONE 11 ZONE 0.</td>	ZONE 13 ZONE 96.	ZONE 11 ZONE 4.	ZONE 11 ZONE 0.
7	ZONE 8	ZONE ID: ZONE 10 % CON ₁ :	ZONE 8 32.	ZONE 6 ZONE 26. <td>ZONE 7 ZONE 11.</td> <td>ZONE 10 ZONE 41.</td> <td>ZONE 8 ZONE 15.</td> <td>ZONE 7 ZONE 3.</td>	ZONE 7 ZONE 11.	ZONE 10 ZONE 41.	ZONE 8 ZONE 15.	ZONE 7 ZONE 3.
10	ZONE 28	ZONE ID: ZONE 28 % CON ₁ :	ZONE 15 77.	ZONE 4B ZONE 8. <td>ZONE 28A ZONE 7.</td> <td>ZONE 28 ZONE 95.<td>ZONE 4B ZONE 2.</td><td>ZONE 15 ZONE 2.</td></td>	ZONE 28A ZONE 7.	ZONE 28 ZONE 95. <td>ZONE 4B ZONE 2.</td> <td>ZONE 15 ZONE 2.</td>	ZONE 4B ZONE 2.	ZONE 15 ZONE 2.
11	ZONE 7	ZONE ID: ZONE 7 % CON ₁ :	ZONE 8 61.	ZONE 6 ZONE 8. <td>ZONE 11 ZONE 2.</td> <td>ZONE 7 ZONE 54.</td> <td>ZONE 6 ZONE 44.</td> <td>ZONE 7 ZONE 1.</td>	ZONE 11 ZONE 2.	ZONE 7 ZONE 54.	ZONE 6 ZONE 44.	ZONE 7 ZONE 1.
12	ZONE 21	ZONE ID: ZONE 23A % CON ₁ :	ZONE 20 28.	ZONE 22 ZONE 26. <td>ZONE 21 ZONE 18.<td>ZONE 23A ZONE 37.</td><td>ZONE 21 ZONE 31.</td><td>ZONE 22 ZONE 16.</td></td>	ZONE 21 ZONE 18. <td>ZONE 23A ZONE 37.</td> <td>ZONE 21 ZONE 31.</td> <td>ZONE 22 ZONE 16.</td>	ZONE 23A ZONE 37.	ZONE 21 ZONE 31.	ZONE 22 ZONE 16.
13	CZ 17	ZONE ID: CZ 17 % CON ₁ :	ZONE 9 39. <td>ZONE 8 ZONE 21.</td> <td>CZ 17 CZ 17.</td> <td>ZONE 9 ZONE 40.</td> <td>ZONE 8 ZONE 6.</td> <td>ZONE 5 ZONE 1.</td>	ZONE 8 ZONE 21.	CZ 17 CZ 17.	ZONE 9 ZONE 40.	ZONE 8 ZONE 6.	ZONE 5 ZONE 1.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

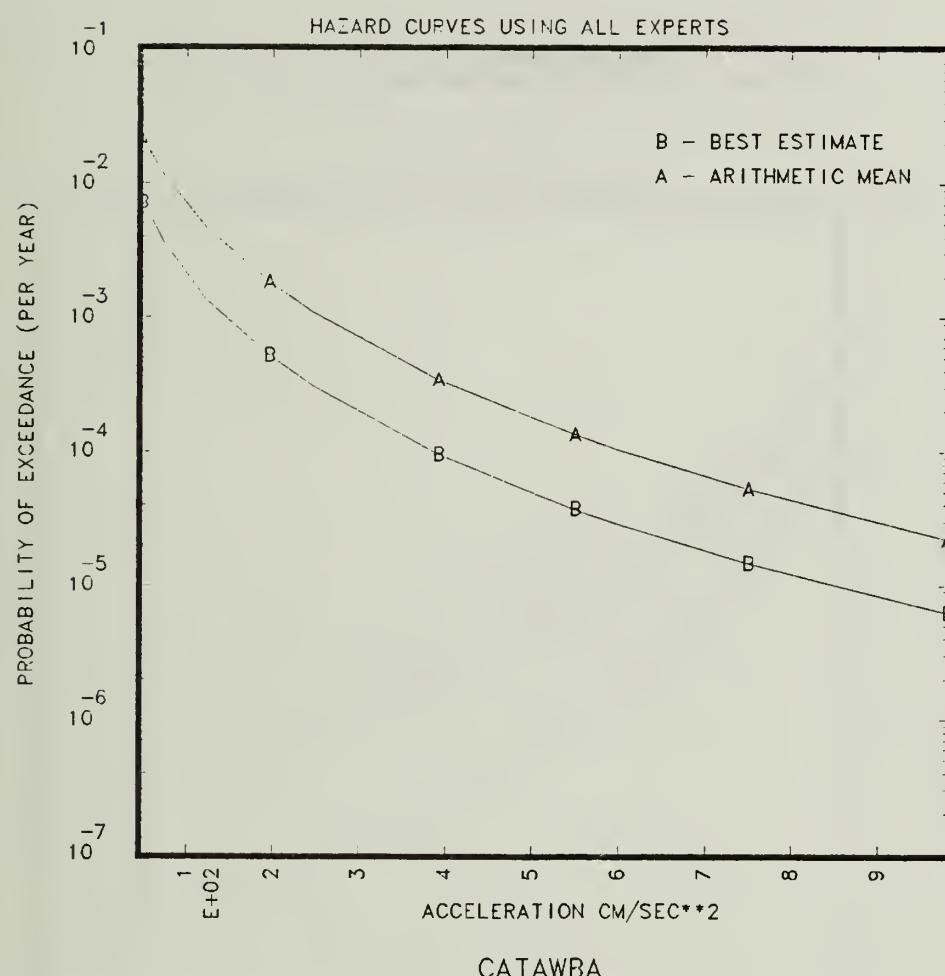


Figure 2.5.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Catawba site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

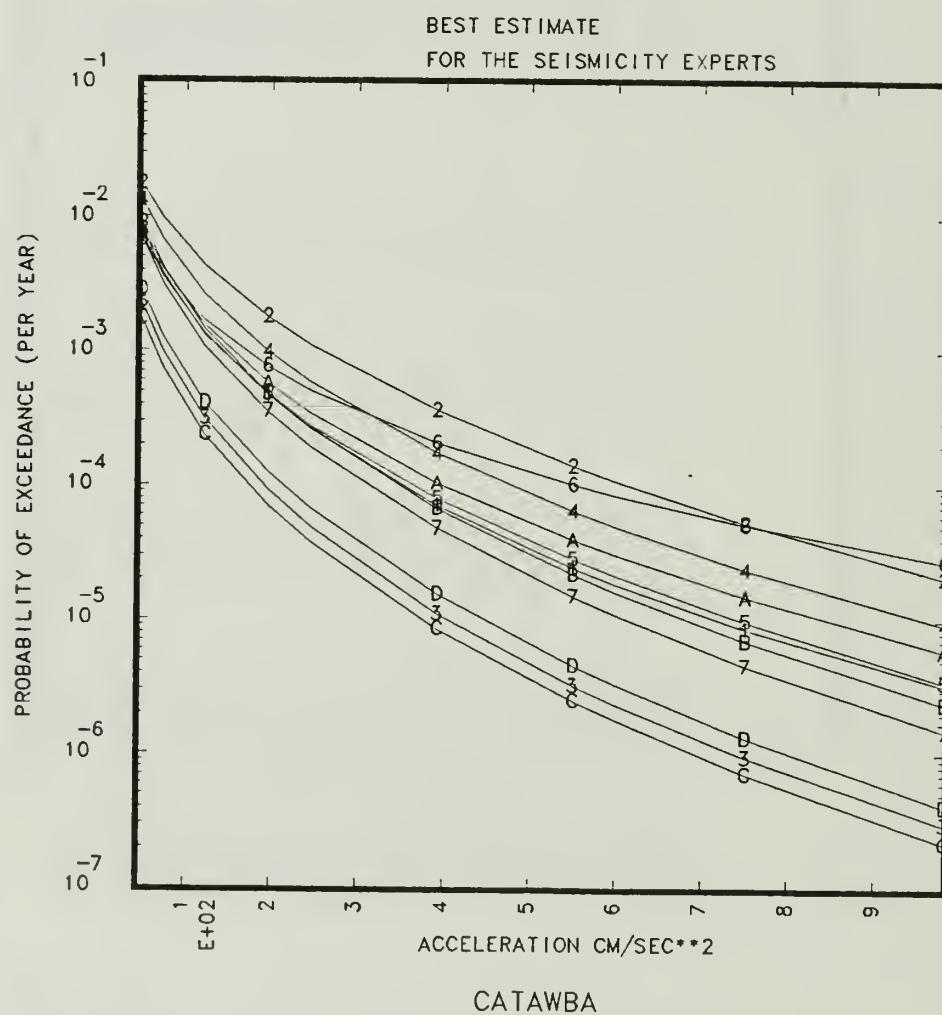


Figure 2.5.2 BEHCs per S-Expert combined over all G-Experts for the Catawba site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

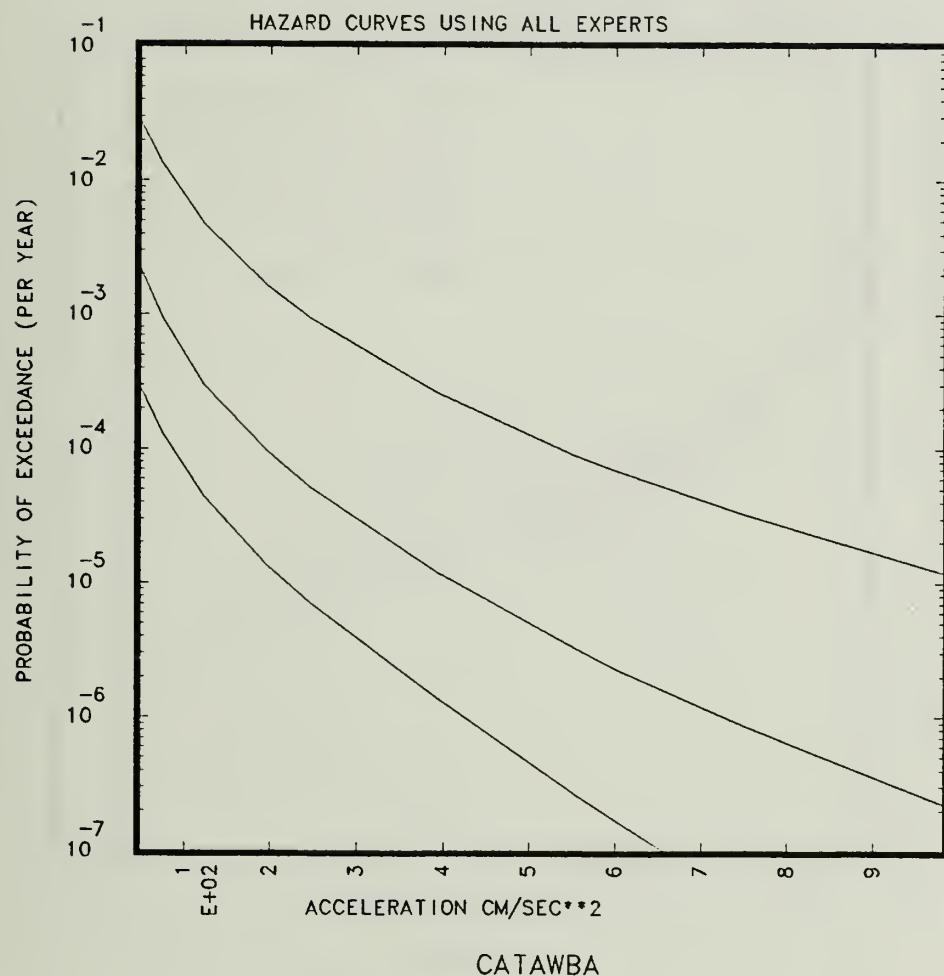


Figure 2.5.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Catawba site.

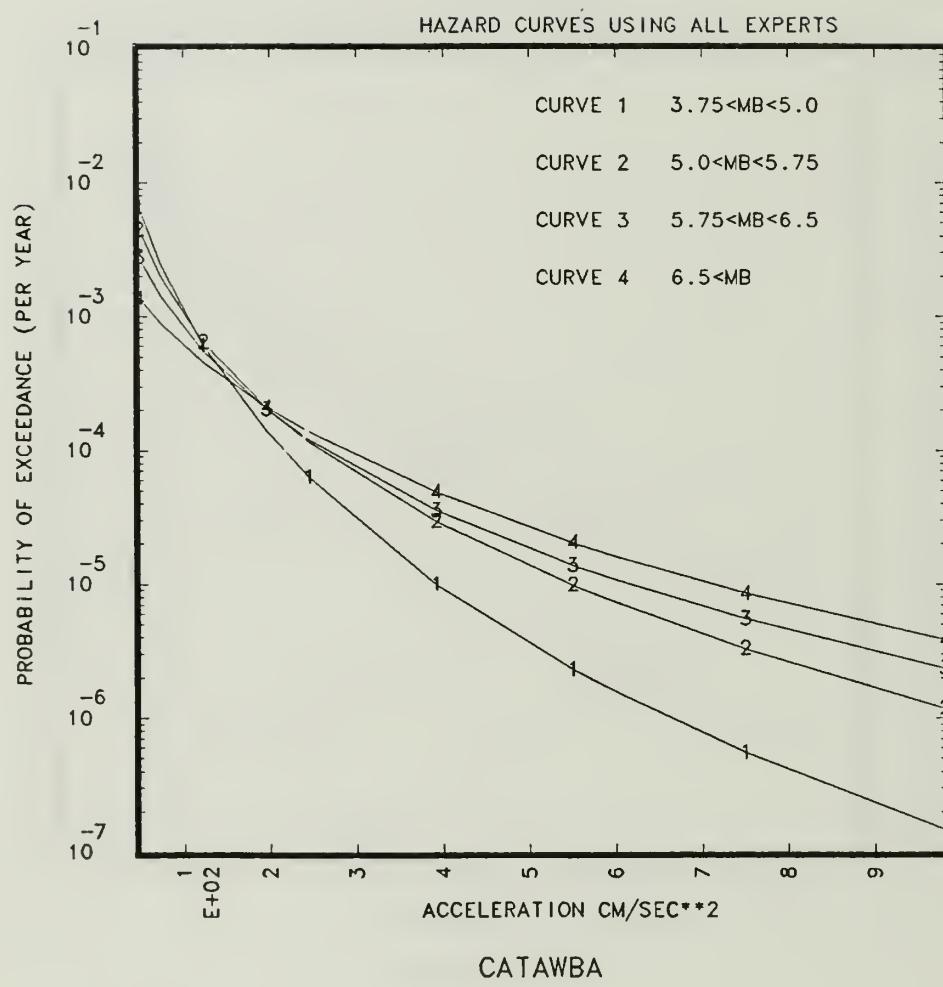


Figure 2.5.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Catawba site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

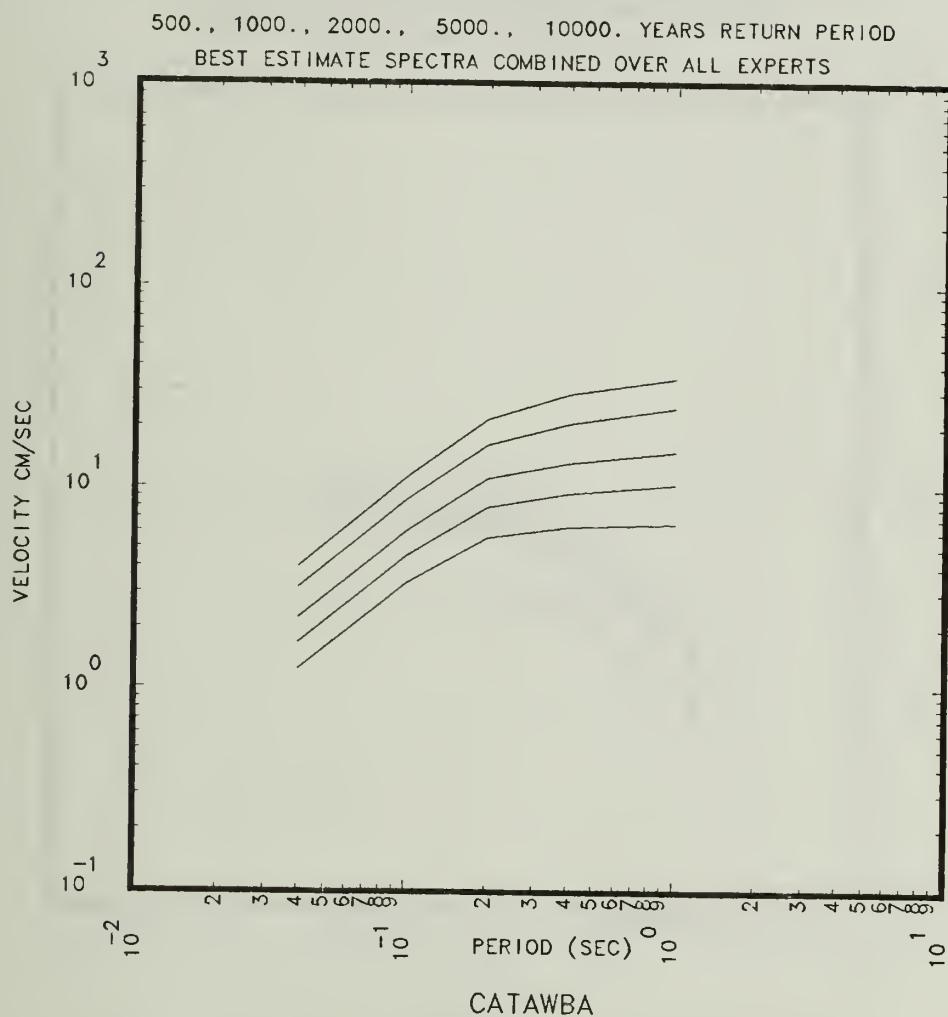


Figure 2.5.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Catawba site.

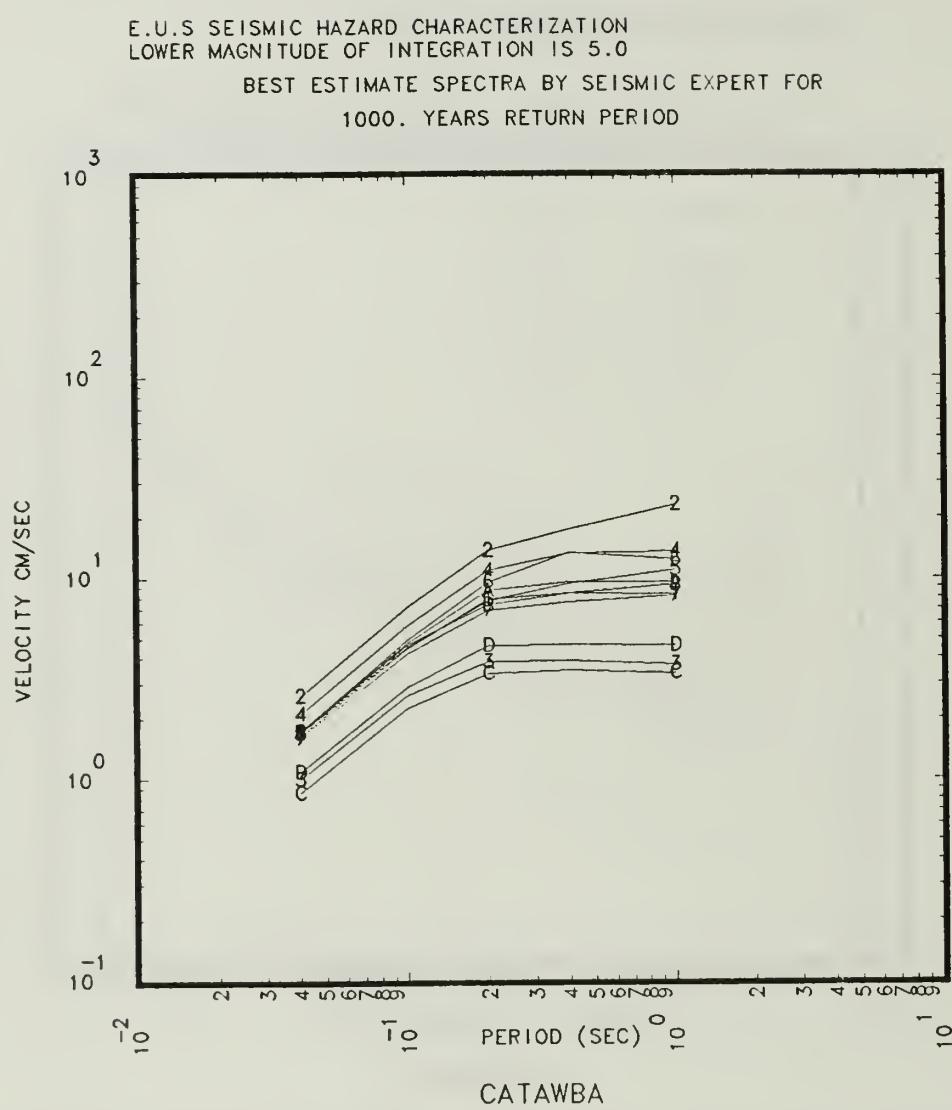


Figure 2.5.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Catawba site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

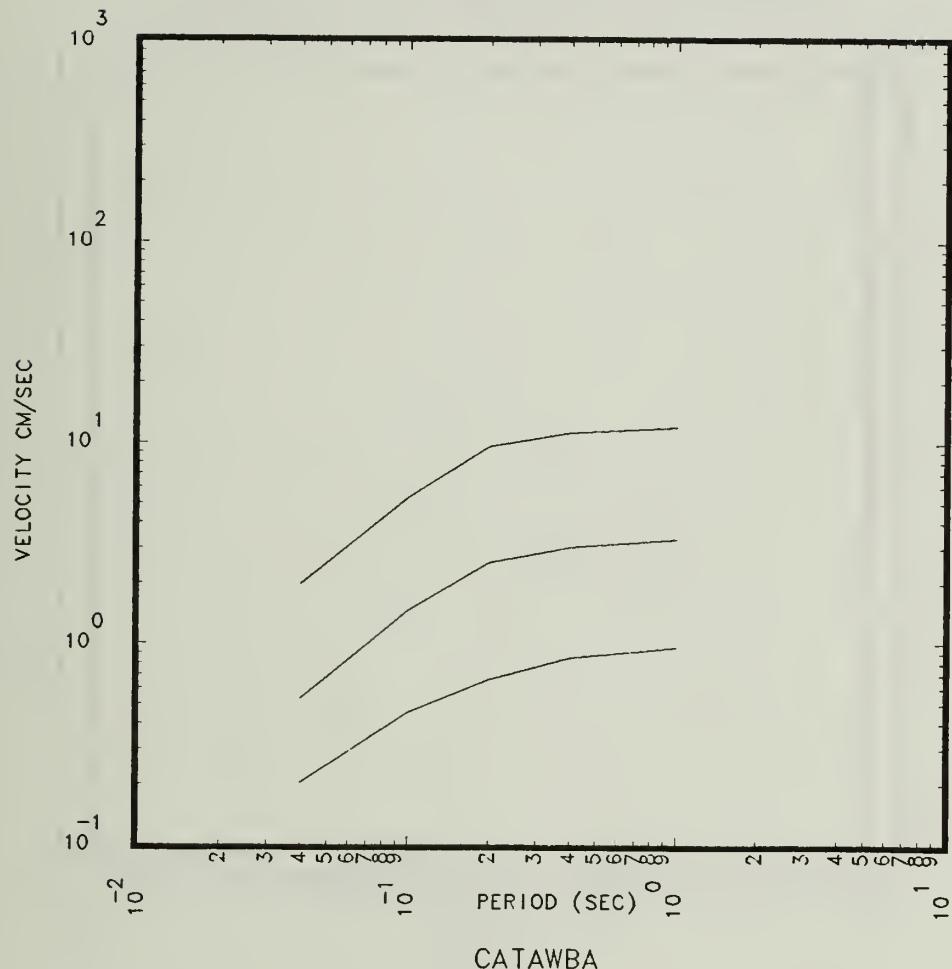


Figure 2.5.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Catawba site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

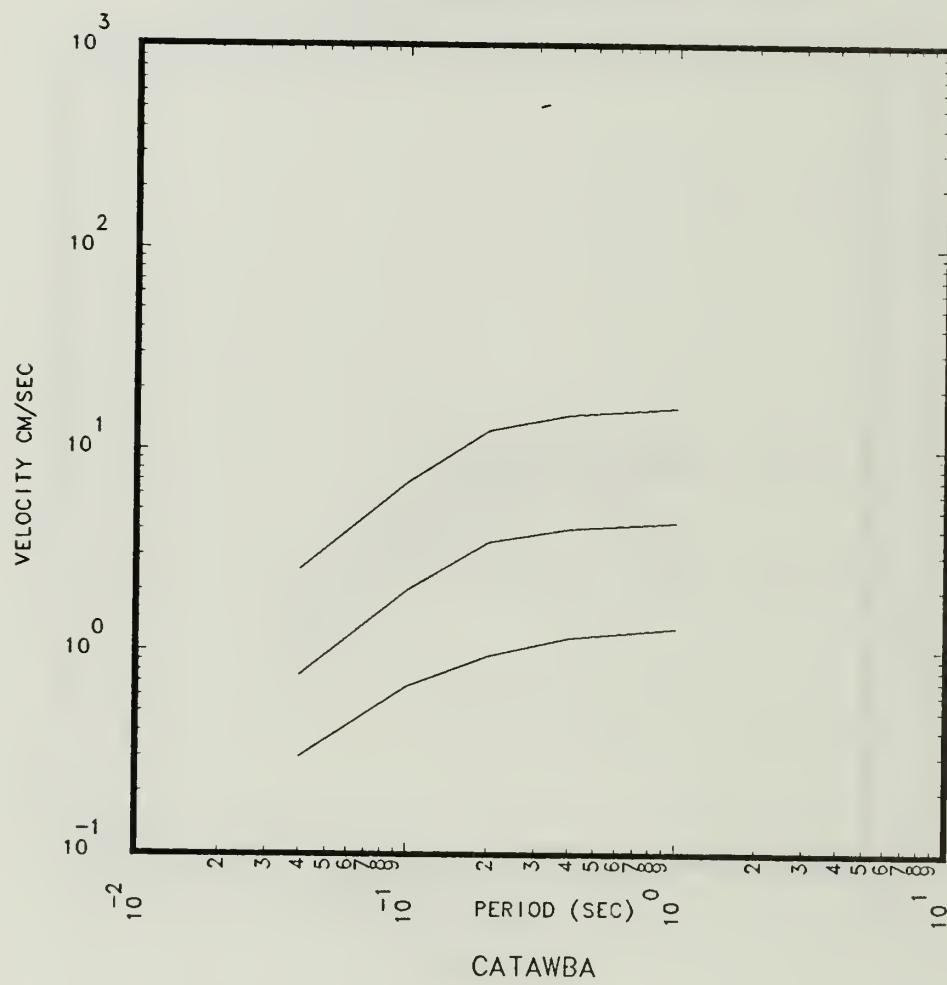


Figure 2.5.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Catawba site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

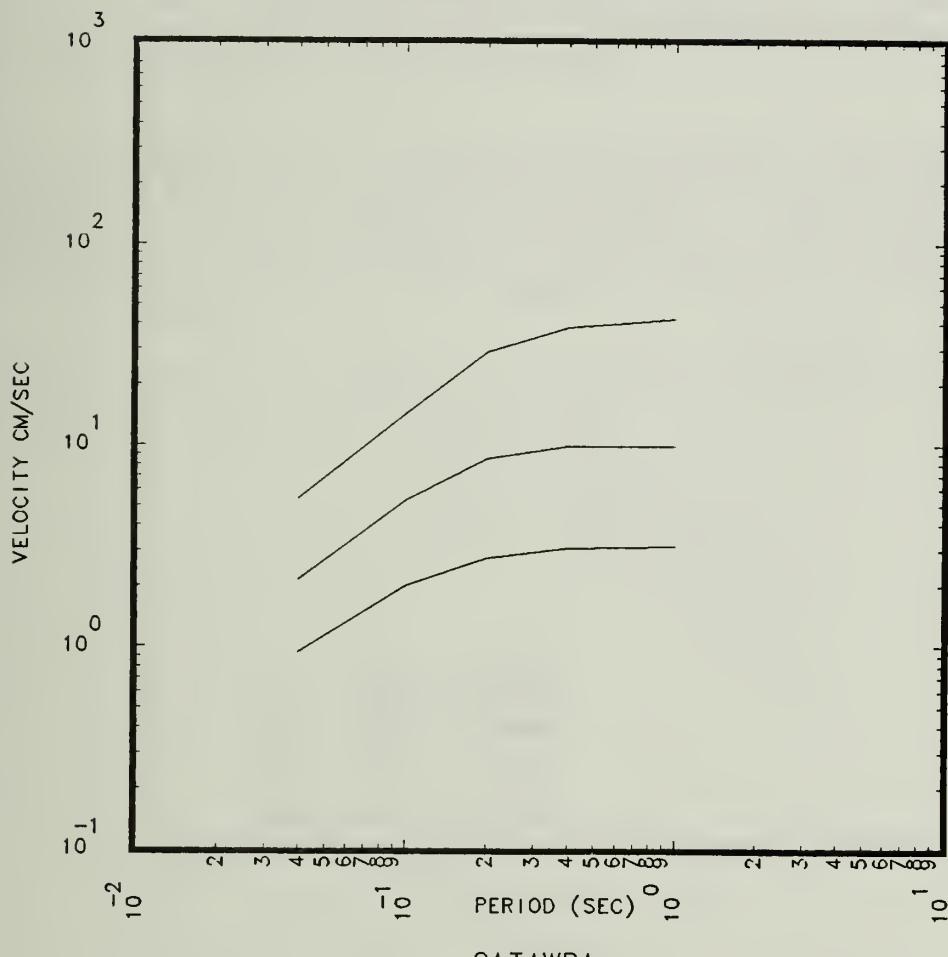


Figure 2.5.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Catawba site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

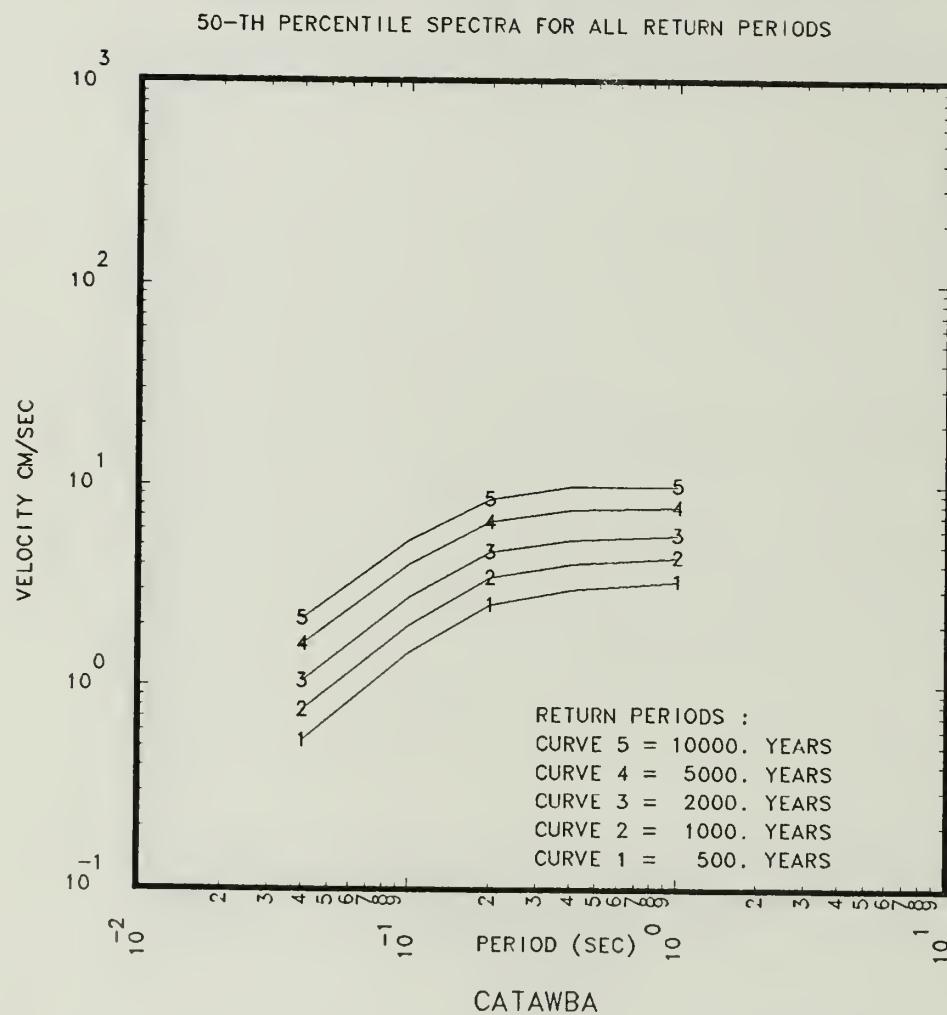


Figure 2.5.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Catawba site.

2.6 FARLEY

Farley is a rock site and is represented by the symbol "6" in Fig. 1.1. Table 2.6.1 and Figs. 2.6.1 to 2.6.10 give the basic results for the Farley site.

Table 2.5.1 shows that the dominant zones in the hazard at Farley are mostly the distant, high upper magnitude cutoff, zones such as the New Madrid and the Charleston zones.

Figure 2.6.2 shows that the spread indicating the diversity of S-Experts' opinion is larger than typical for this site in part due to the low estimates for expert 12 (symbol "C") and the high estimate for expert 11 (symbol "B"). S-Expert 12's BEHC is low because Farley is in S-Expert 12's Zone 26 which has upper magnitude cutoff of less than 5. Thus S-Expert 12's Zone 26 does not contribute to the hazard at the Farley Site.

Figure 2.6.4 shows that the large earthquakes (greater than magnitude 6.5) are the ones which contribute the most to the hazard. On the contrary the small earthquakes (less than magnitude 5.0) contribute so little that they practically do not affect the hazard at this site. Thus if small earthquakes were included there would be little change in the BEHC for the Farley Site.

In addition to the above comments, all the typical comments for a rock site (see Section 2.1) apply also for this site.

TABLE 2.6.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR FARLEY

SITE SOIL CATEGORY ROCK

S-EXP. HOST NUM.	HOST ZONE	ZONES CONTRIBUTING AT LOW PGA(0.125G)	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT HIGH PGA(0.60G)
1	ZONE 1	ZONE 1 % CONT.: 48.	ZONE 9 ZONE 5. ZONE 10 ZONE 5.
2	COMP. Z0	ZONE ID: ZONE 18 % CONT.: 46.	ZONE 30 COMP. Z0N ZONE 27 ZONE 8. ZONE 18 ZONE 60.
3	ZONE 8A	ZONE ID: ZONE 8A % CONT.: 57.	ZONE 5 ZONE 13 ZONE 9 ZONE 9. ZONE 10. ZONE 9.
4	ZONE 25	ZONE ID: ZONE 4 % CONT.: 69.	ZONE 10 ZONE 9 ZONE 8 ZONE 7. ZONE 9.
5	ZONE 8	ZONE ID: ZONE 9 % CONT.: 39.	ZONE 15 ZONE 10 ZONE 11 ZONE 18. ZONE 6.
6	COMP. Z0	ZONE ID: ZONE 13 % CONT.: 60.	ZONE 18 ZONE 9. ZONE 17 ZONE 9. ZONE 16.
7	ZONE 2 =	ZONE ID: ZONE 6 % CONT.: 77.	ZONE 10 ZONE 2 = ZONE 7 ZONE 3. ZONE 6. ZONE 12A ZONE 18. ZONE 9.
10	ZONE 19	ZONE ID: ZONE 19 = ZONE 28 % CONT.: 64.	ZONE 12A ZONE 4B ZONE 5. ZONE 9. ZONE 6. ZONE 19 = ZONE 28 ZONE 96. ZONE 2.
11	ZONE 8	ZONE ID: ZONE 8 % CONT.: 90.	ZONE 11 ZONE 2. ZONE 6. ZONE 2. ZONE 8 ZONE 100.
12	ZONE 26	ZONE ID: ZONE 23A % CONT.: 30.	ZONE 19 ZONE 25 ZONE 25. ZONE 18. ZONE 6. ZONE 15. ZONE 47.
13	CZ 16	ZONE ID: ZONE 5 % CONT.: 47.	ZONE 8 CZ 16 ZONE 16. ZONE 15. CZ 16 ZONE 57. ZONE 29. ZONE 8. ZONE 4.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

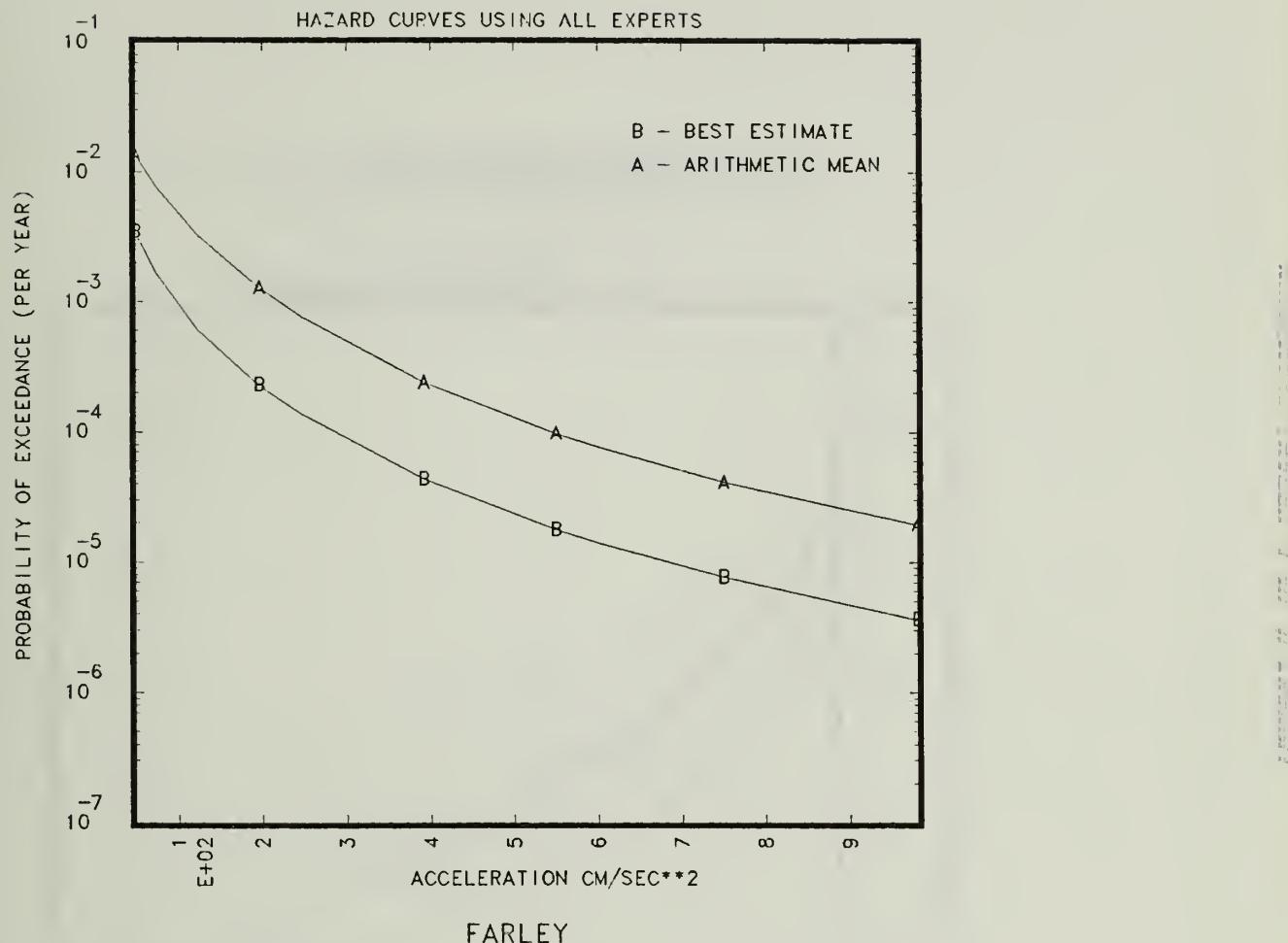


Figure 2.6.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Farley site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

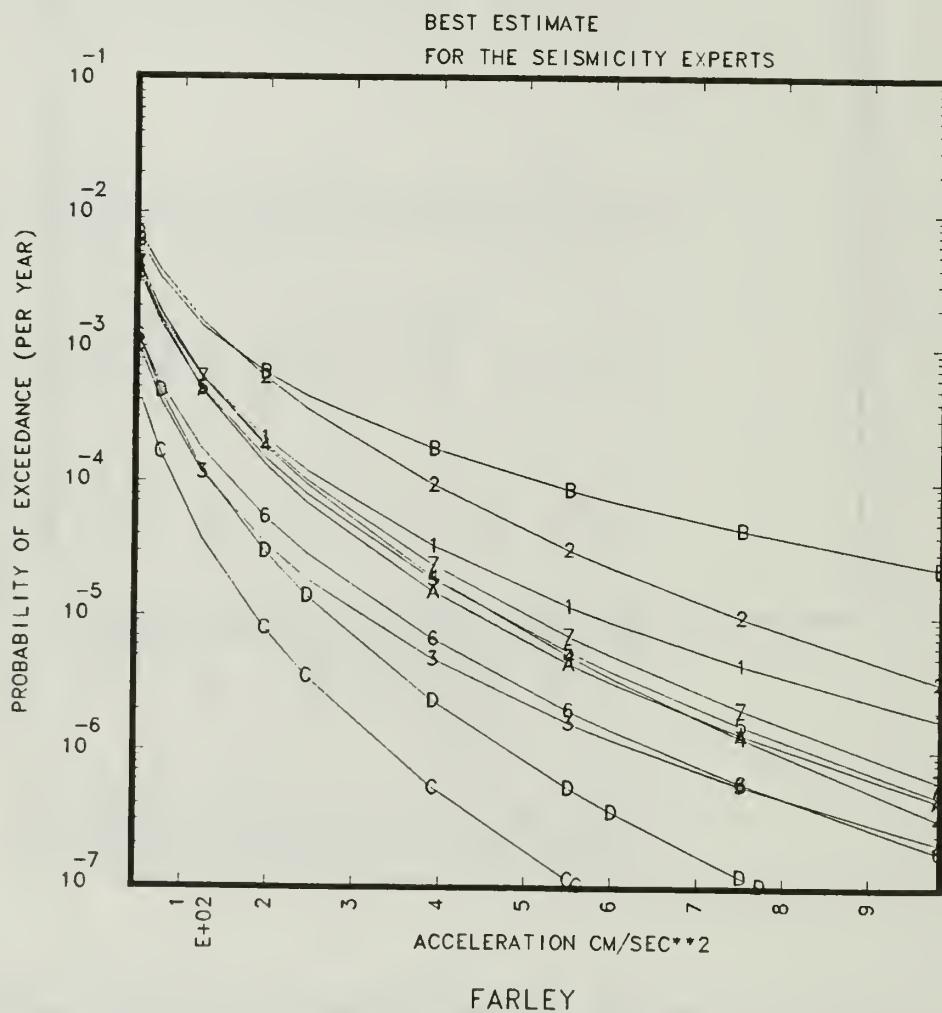


Figure 2.6.2 BEHCs per S-Expert combined over all G-Experts for the Farley site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

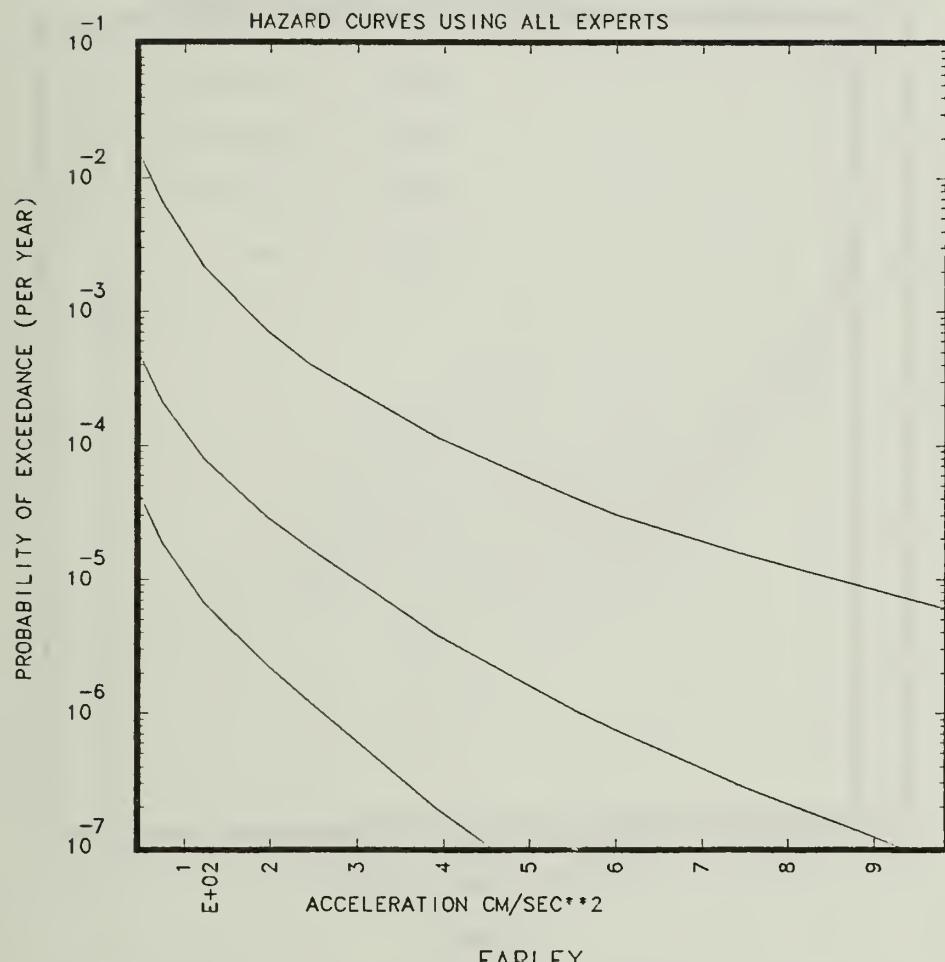


Figure 2.6.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Farley site.

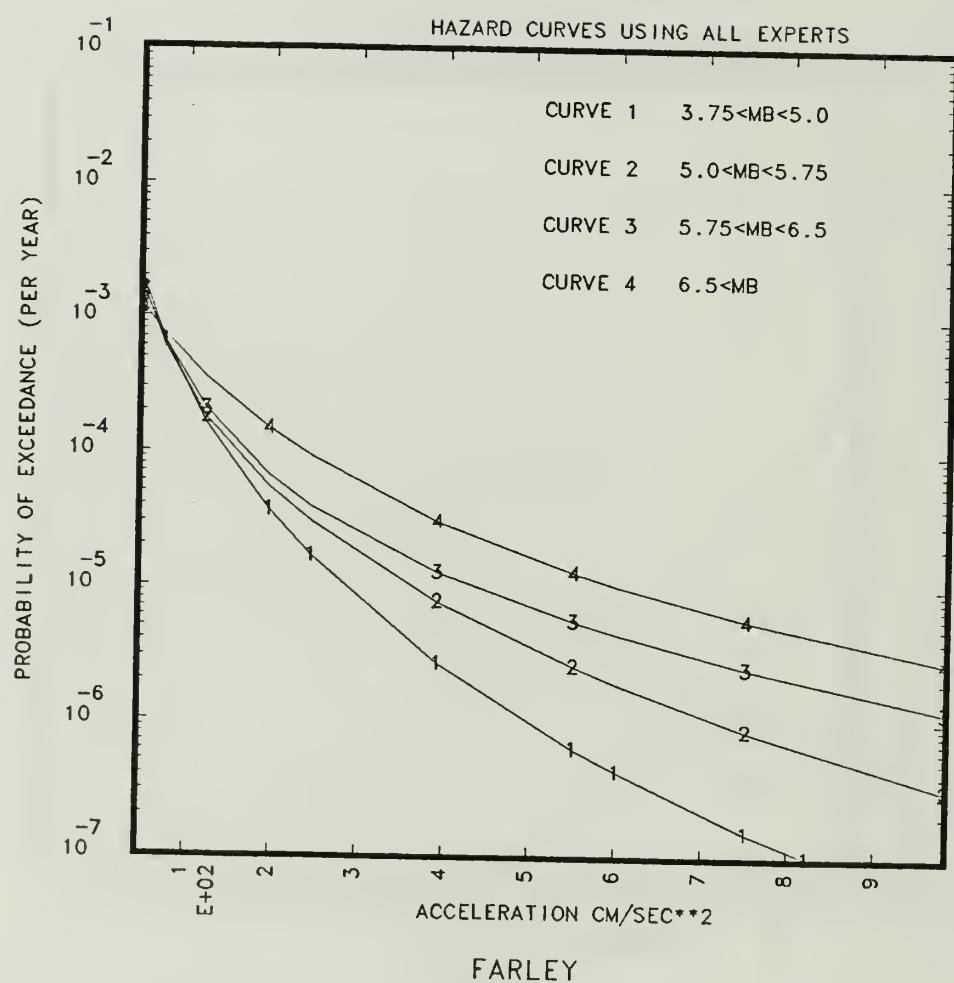


Figure 2.6.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Farley site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

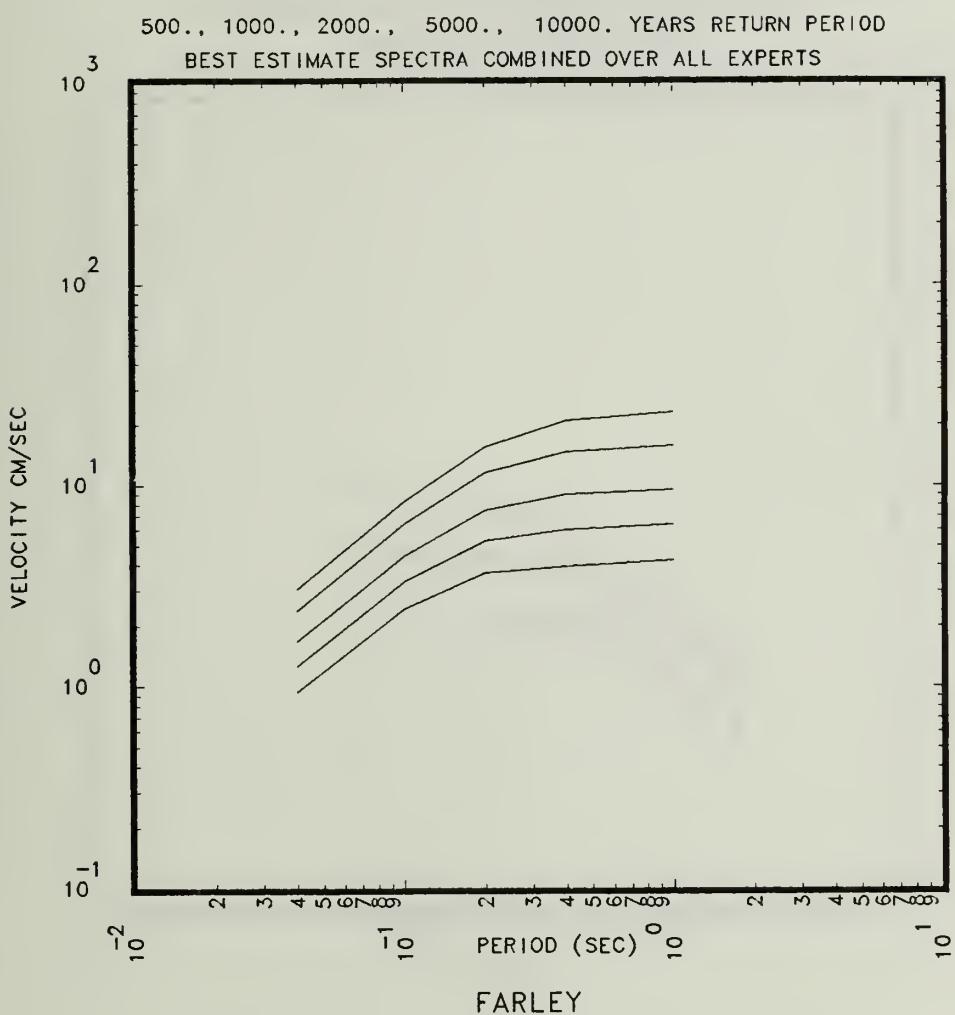


Figure 2.6.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Farley site.

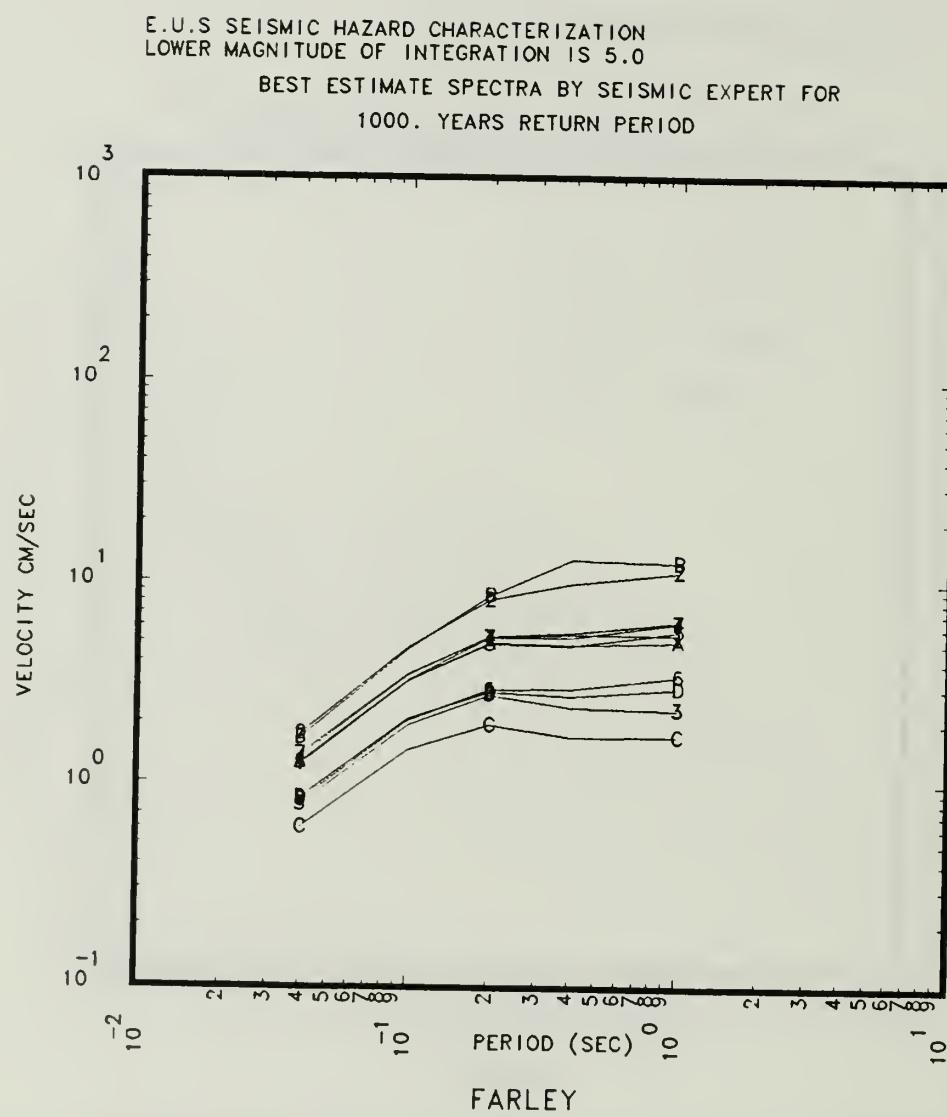


Figure 2.6.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Farley site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

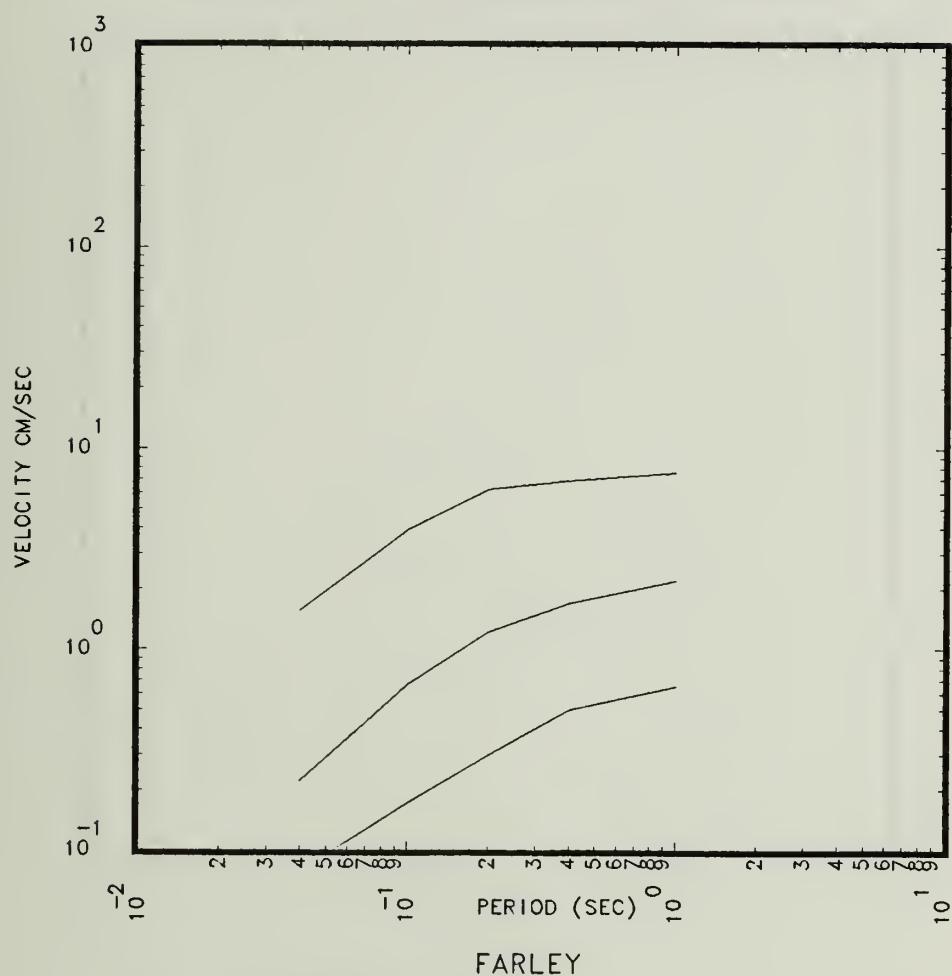


Figure 2.6.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Farley site.

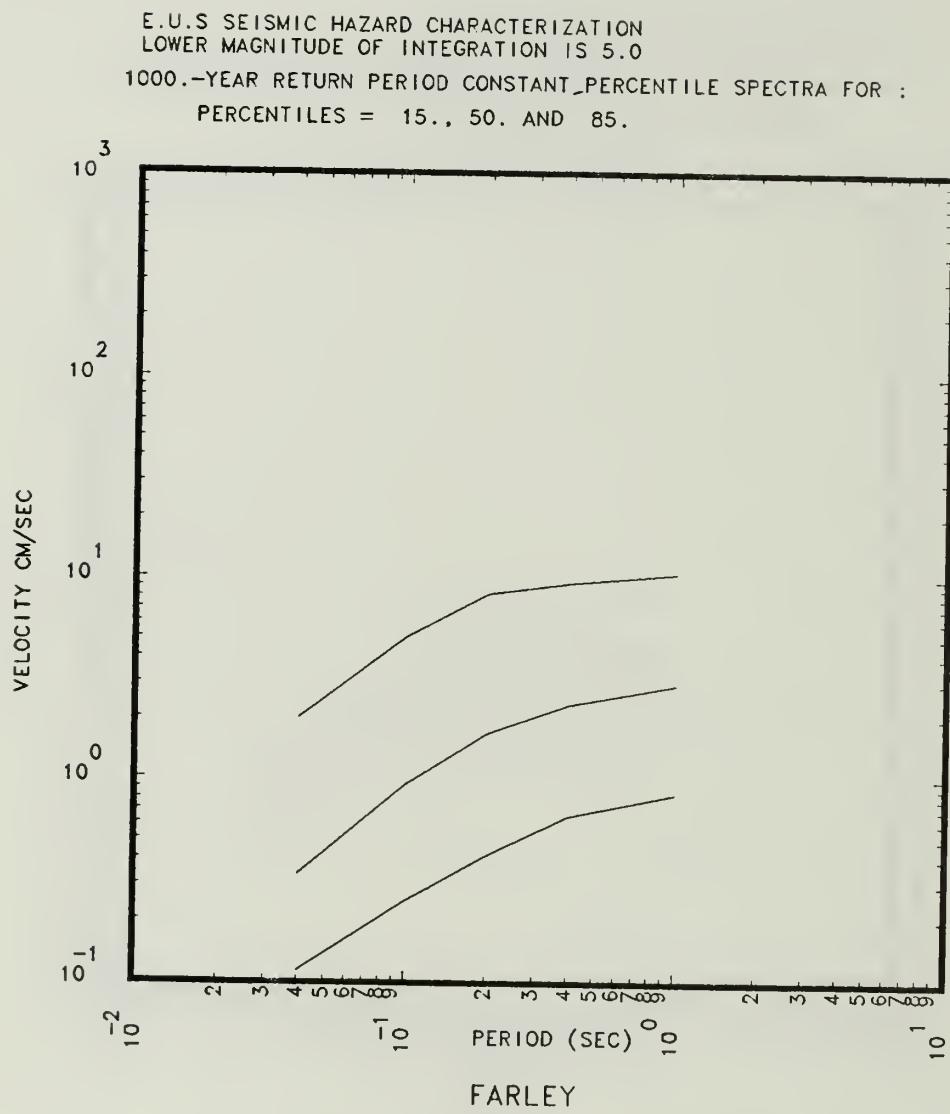


Figure 2.6.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Farley site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

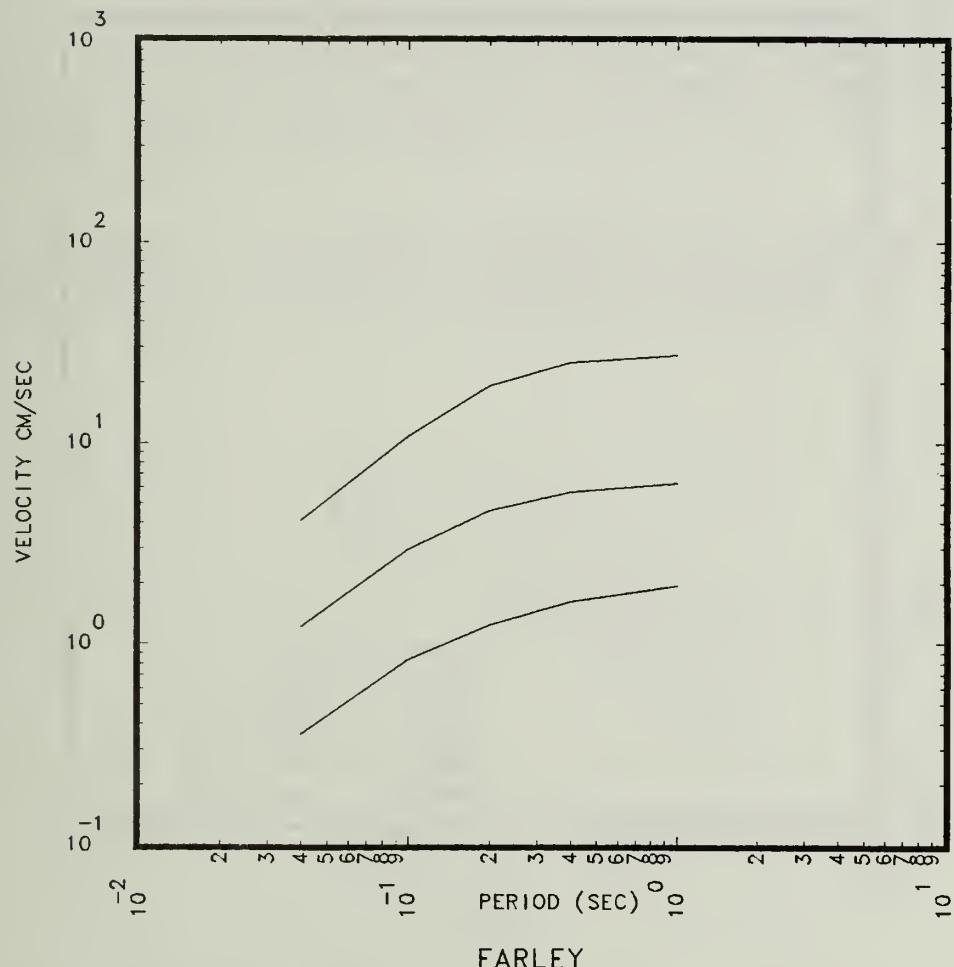


Figure 2.6.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Farley site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

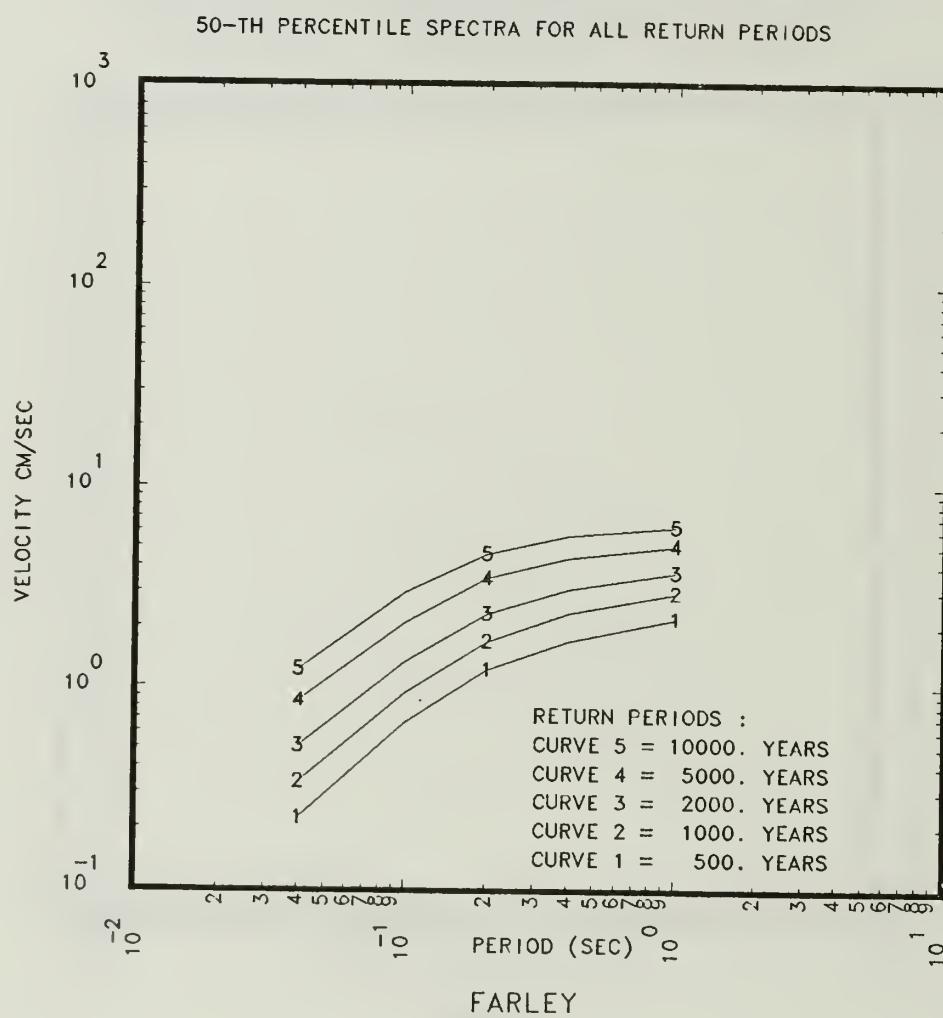


Figure 2.6.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Farley site.

2.7 HATCH

Hatch is a deep soil site represented by the symbol "7" in the location map in Fig. 1.1. Table 2.7.1 and Figs. 2.7.1 to 2.7.10 give the basic results for the Hatch site.

Table 2.5.1 and the maps in Appendix B show that the site is located in large seismic zones for most S-Experts. However, the smaller zones with high magnitude cutoffs such as the Charleston area and to a lesser extent the New Madrid area, contribute significantly to the hazard.

The spread in the BEHC for each S-Expert shown in Fig. 2.7.2 indicates a higher than typical diversity of opinions for this site due, in particular, to the high estimates for S-Experts 2 and 11's (symbol "B") input. For S-Expert 2, the site is located in the complementary zone (CZ), however, zone 30, which includes Charleston, dominates the hazard. For Expert 11 the site is in Zone 8, which is an extended Charleston zone, indicating that a "Charleston-like" earthquake can occur anywhere in Zone 8.

Figure 2.7.4 shows that the highest contribution to the hazard at this site is from large earthquakes (greater than magnitude 6.5) and that the small earthquakes (lower than 5.0) do not contribute significantly.

TABLE 2.7.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR HATCH

SITE SOIL CATEGORY DEEP-SOIL

S-XPT NUM.	HOST ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)
1	ZONE 1 % CONT.:	ZONE 1: ZONE 1 26. ZONE 2: ZONE 12. ZONE 3: ZONE 9 ZONE 4: ZONE 94. ZONE 5: ZONE 1.
2	COMP. Z0 % CONT.:	ZONE ID: ZONE 30 16. ZONE 29: ZONE 18 COMP. ZON 8. ZONE 30: ZONE 29 COMP. ZON 81. ZONE 31: ZONE 12. ZONE 32: ZONE 6.
3	ZONE 8 % CONT.:	ZONE ID: ZONE 9 37. ZONE 8A: ZONE 8 ZONE 13 ZONE 36: ZONE 24. ZONE 37: ZONE 7.
4	ZONE 25 % CONT.:	ZONE ID: ZONE 10 25. ZONE 4: ZONE 9 ZONE 25 ZONE 5: ZONE 10. ZONE 6: ZONE 39. ZONE 7: ZONE 50.
5	ZONE 8 % CONT.:	ZONE ID: ZONE 9 65. ZONE 8: ZONE 8 ZONE 15 ZONE 9: ZONE 10. ZONE 10: ZONE 83. ZONE 11: ZONE 10. ZONE 12: ZONE 6.
6	COMP. Z0 % CONT.:	ZONE ID: ZONE 13 85. ZONE 14: ZONE 11 COMP. ZON 6. ZONE 15: ZONE 11. ZONE 16: ZONE 91.
7	ZONE 2 = % CONT.:	ZONE ID: ZONE 10 68. ZONE 6: ZONE 23. ZONE 7: ZONE 21. ZONE 8: ZONE 2 = ZONE 8 ZONE 9: ZONE 1. ZONE 10: ZONE 10. ZONE 11: ZONE 81. ZONE 12: ZONE 6.
10	ZONE 4B % CONT.:	ZONE ID: ZONE 4B 74. ZONE 15: ZONE 28 ZONE 19 = ZONE 21: ZONE 3. ZONE 22: ZONE 1. ZONE 23: ZONE 1. ZONE 24: ZONE 4B ZONE 15 ZONE 19 = ZONE 5 ZONE 25: ZONE 98.
11	ZONE 8 % CONT.:	ZONE ID: ZONE 8 99. ZONE 11: ZONE 7 CZ = ZONE 0. ZONE 12: ZONE 0. ZONE 13: ZONE 8 CZ = ZONE 100. ZONE 14: ZONE 5 ZONE 0.
12	ZONE 25 % CONT.:	ZONE ID: ZONE 23A 54. ZONE 24: ZONE 25 ZONE 23 ZONE 26: ZONE 15. ZONE 27: ZONE 46. ZONE 28: ZONE 7.
13	CZ 17 % CONT.:	CZ ID: CZ 17 65. ZONE 9: ZONE 5 ZONE 8 ZONE 10: ZONE 1. ZONE 11: ZONE 2. ZONE 12: ZONE 83. ZONE 13: ZONE 15. ZONE 14: CZ 15. ZONE 15: ZONE 5 ZONE 0.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

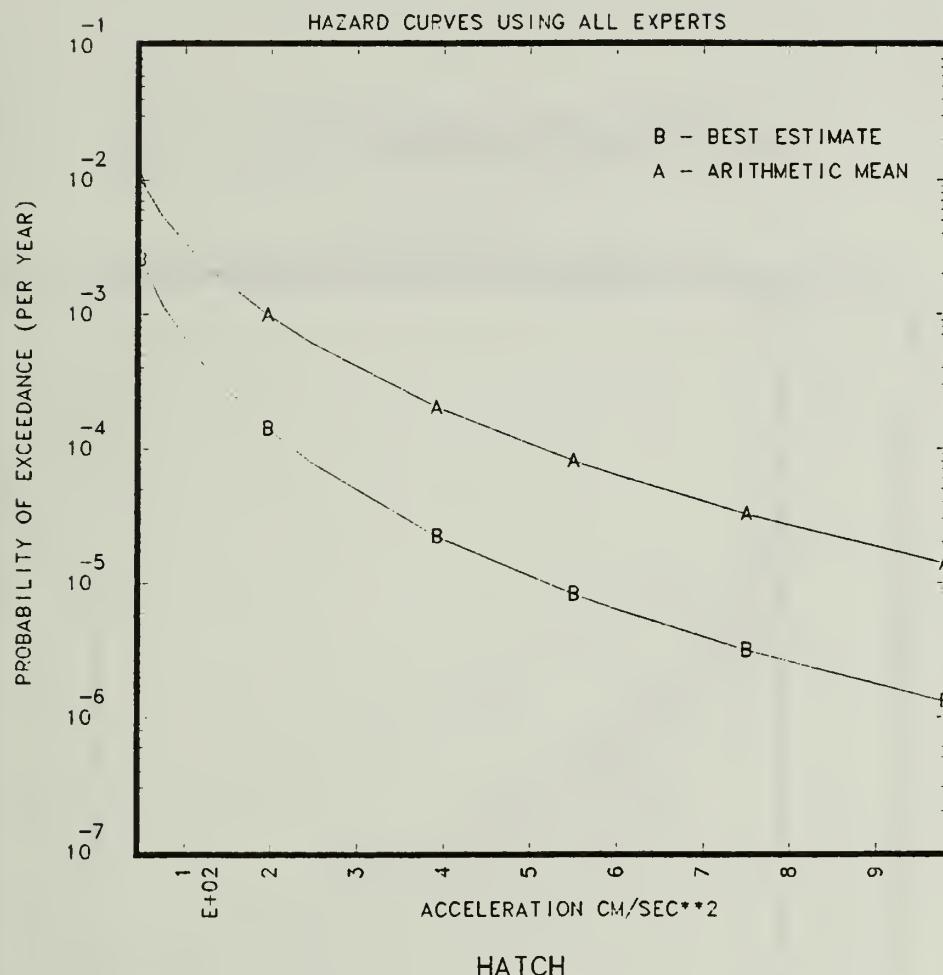


Figure 2.7.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Hatch site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

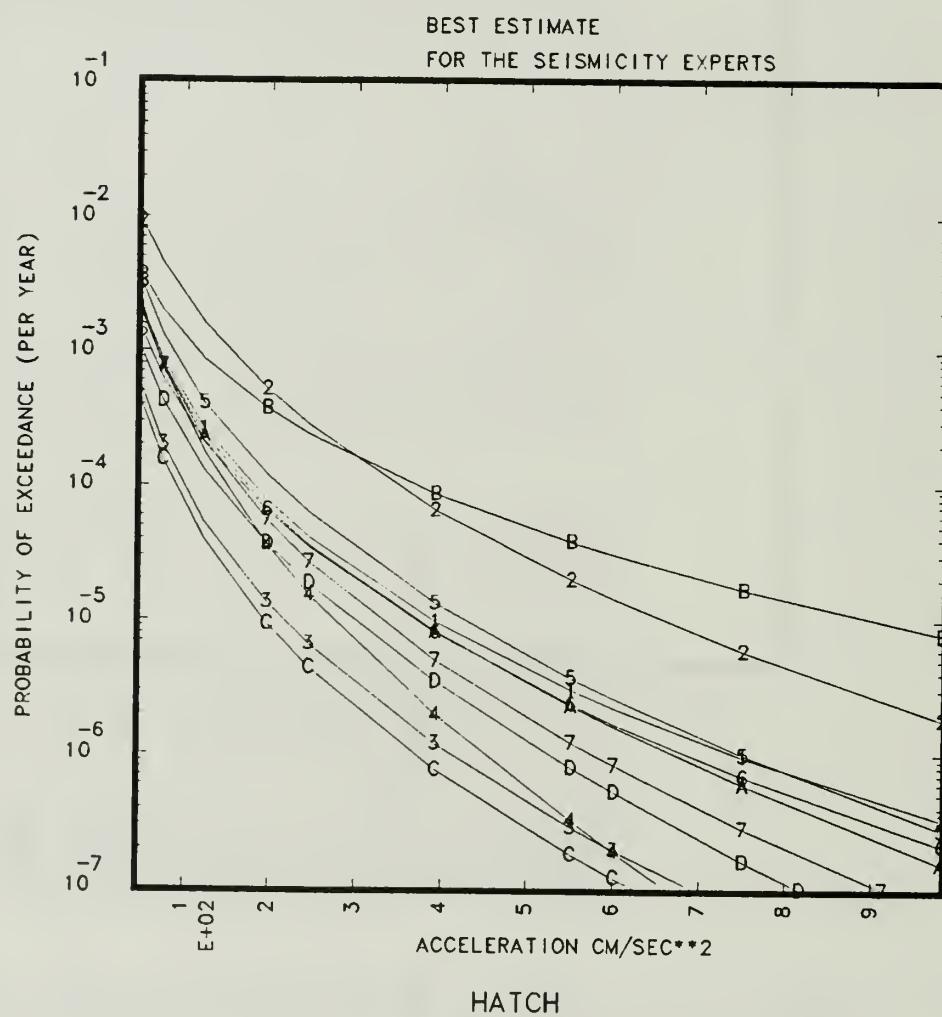


Figure 2.7.2 BEHCs per S-Expert combined over all G-Experts for the Hatch site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

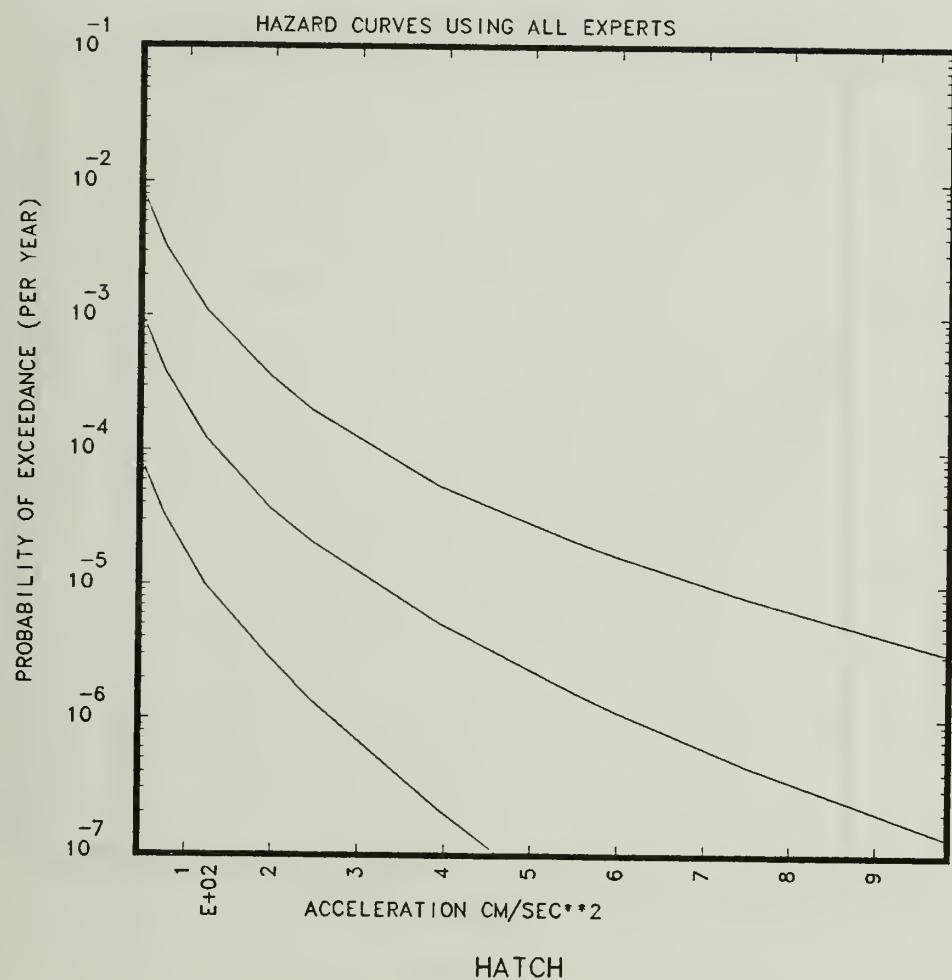


Figure 2.7.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Hatch site.

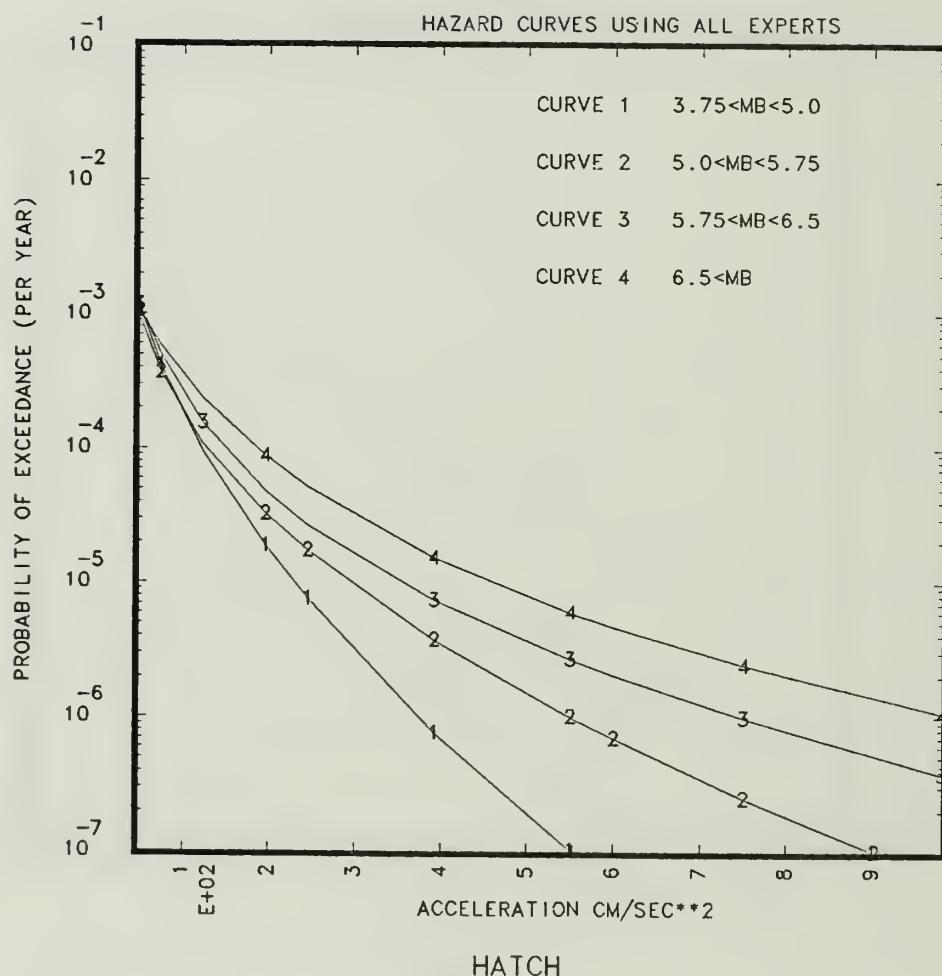


Figure 2.7.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Hatch site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

500., 1000., 2000., 5000., 10000. YEARS RETURN PERIOD
BEST ESTIMATE SPECTRA COMBINED OVER ALL EXPERTS

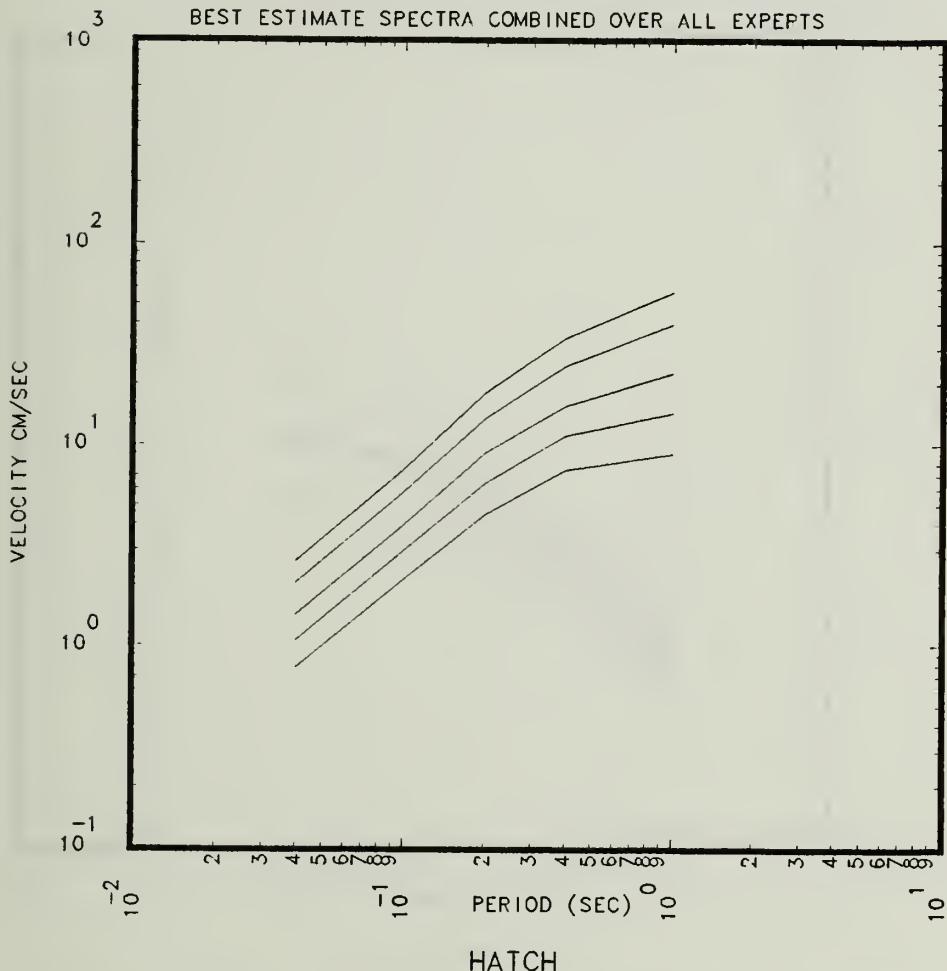


Figure 2.7.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Hatch site.

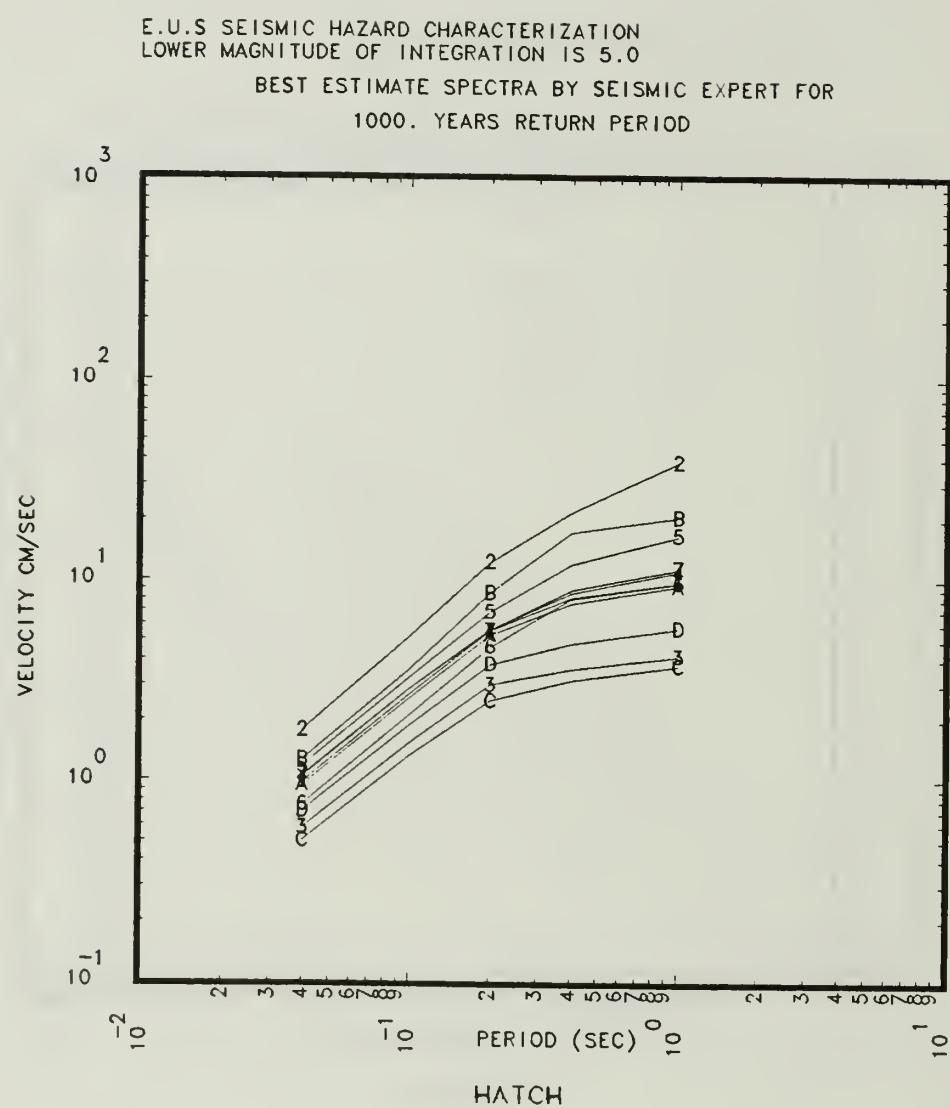


Figure 2.7.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Hatch site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

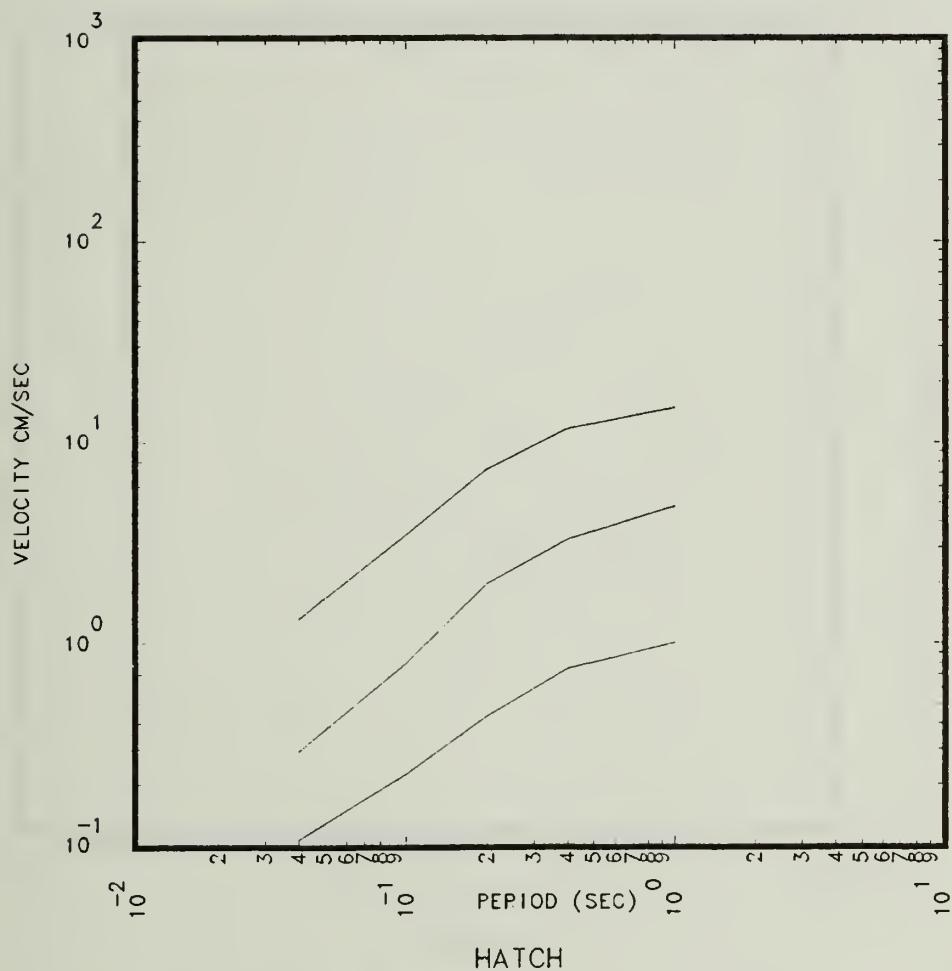


Figure 2.7.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Hatch site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD, CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

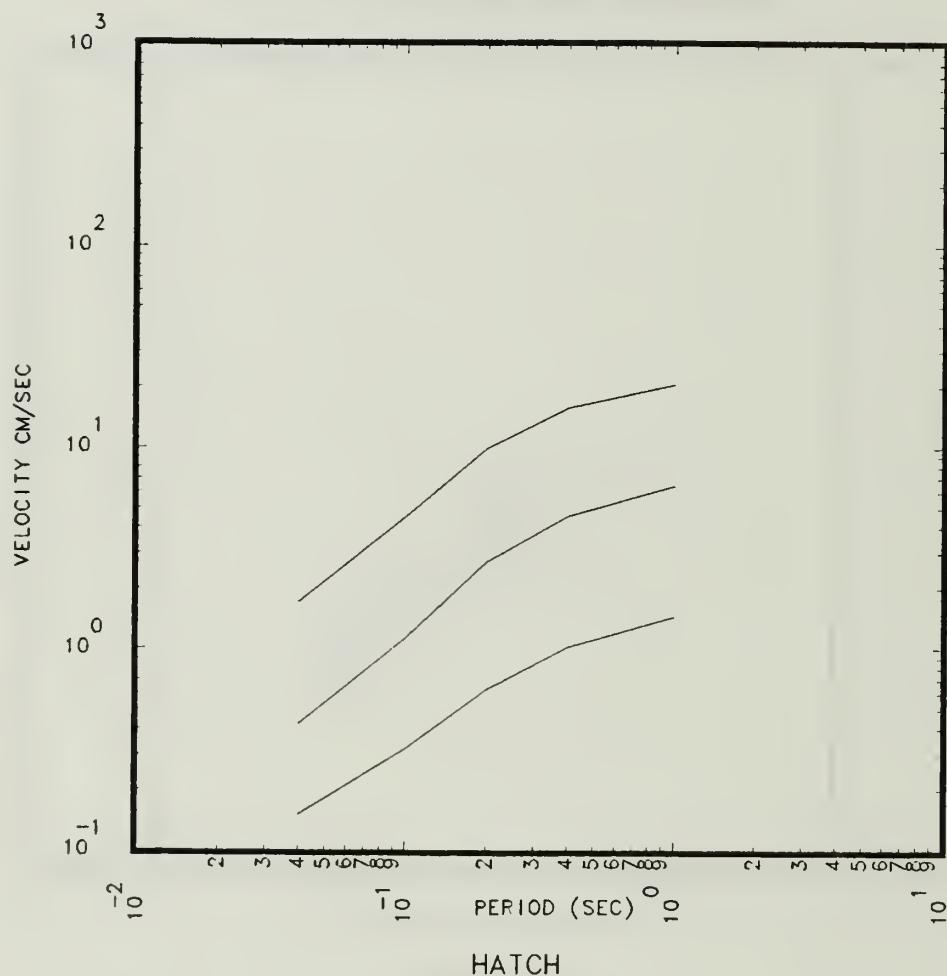


Figure 2.7.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Hatch site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

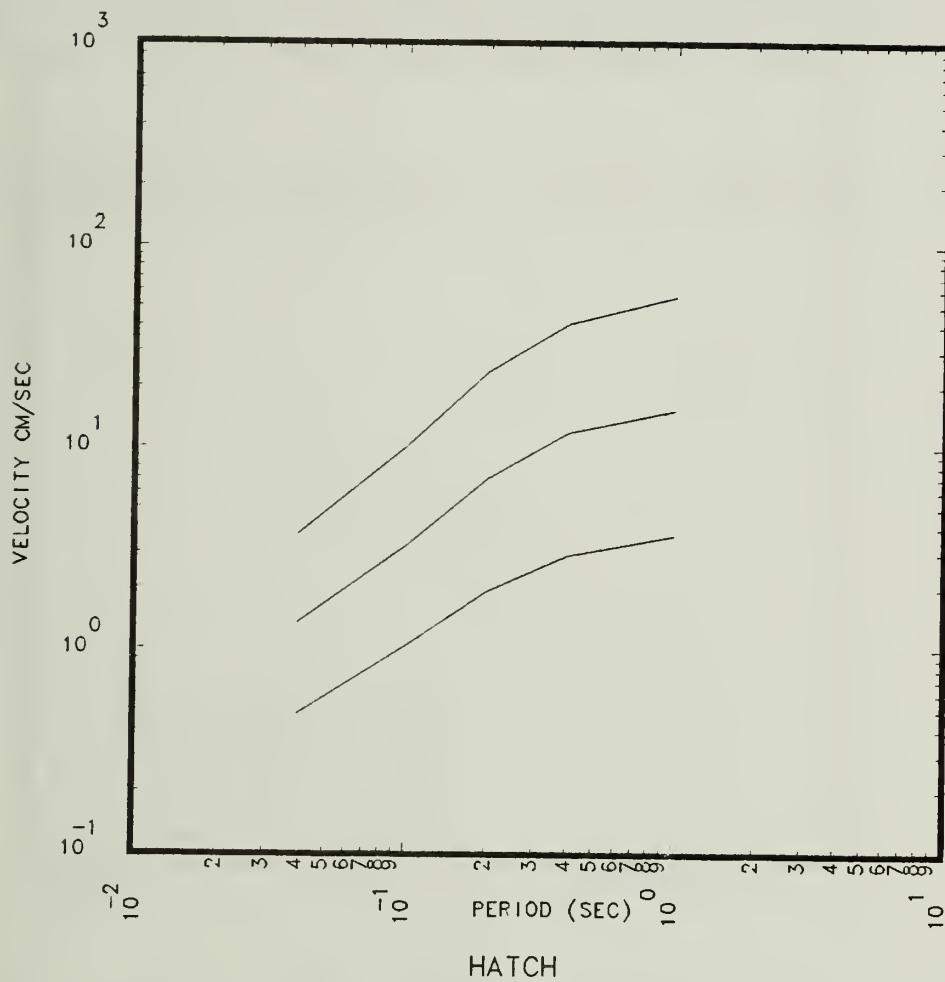


Figure 2.7.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Hatch site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

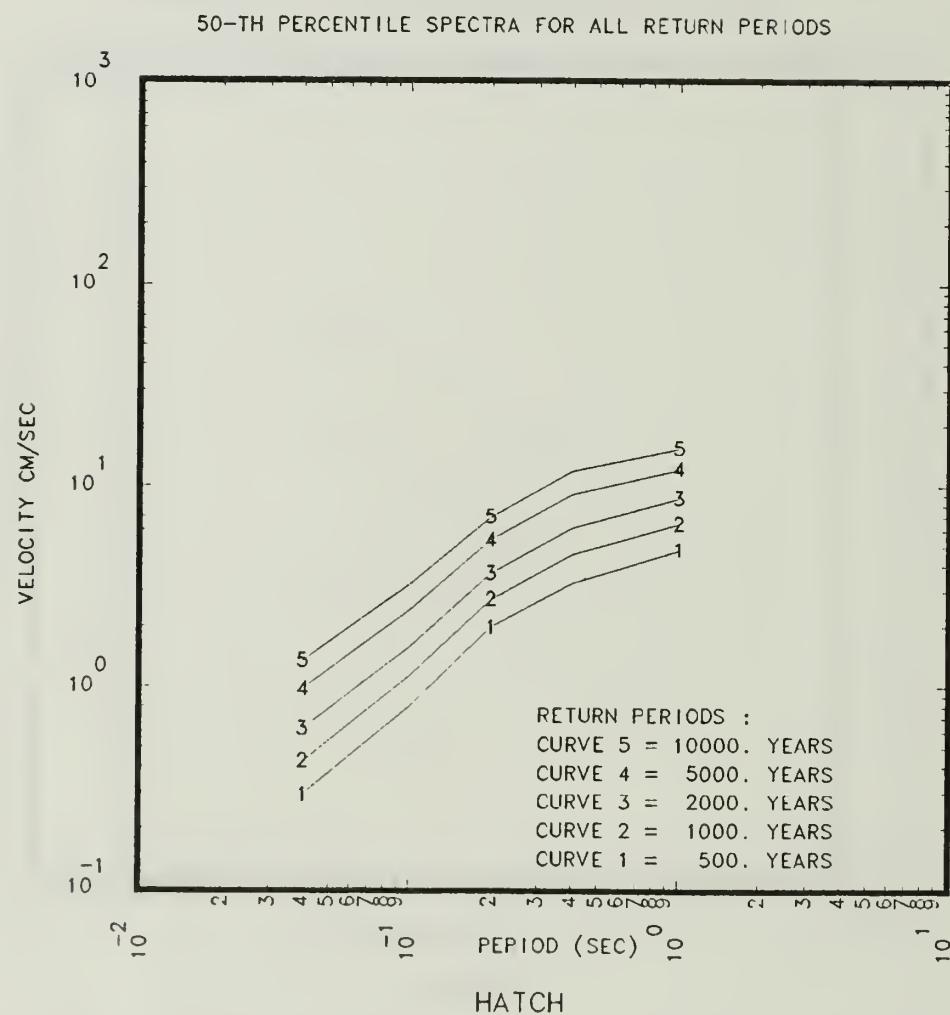


Figure 2.7.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Hatch site.

2.8 McGuire

McGuire is a rock site represented by the symbol "8" in the location map of Fig. 1.1. Table 2.8.1 and Figs. 2.8.1 to 2.8.10 give the basic results for the McGuire site.

Table 2.8.1 shows that the Charleston area zones dominate the hazard. Figure 2.8.2 shows a typical spread of the BEHC per S-Expert, and Fig. 2.8.3 exhibits also a typical spread between the 15th and 85th percentile CPHC for region 2 (southeast) sites.

Figure 2.8.4 shows that for PGA values greater than 0.15g, all earthquakes ranges above magnitude 5.0 contribute equally to the hazard and the small earthquakes (smaller than magnitude 5.0) do not contribute significantly. On the contrary, for PGA values below 0.15g, the small earthquakes contribute the most.

In addition to the above comments, all the typical comments for rock site apply to McGuire (See Section 2.1).

TABLE 2.8.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR MC GUIRE

SITE SOIL CATEGORY ROCK

Si-XPT NUM.	HOST ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)
1	ZONE 3	ZONE ID: ZONE 3 % CONT.: 55.
		ZONE 2 19. 12.
2	ZONE 29	ZONE ID: ZONE 30 % CONT.: 49.
		ZONE 29 14. 24.
3	ZONE 7	ZONE ID: ZONE 7 % CONT.: 55.
		ZONE 5 20. 19.
4	ZONE 11	ZONE ID: ZONE 10 % CONT.: 47.
		ZONE 9 23. 13.
5	ZONE 10	ZONE ID: ZONE 9 % CONT.: 62.
		ZONE 10 22. 8.
6	COMP. 20	ZONE ID: ZONE 13 % CONT.: 65.
		ZONE 11 30. 1.
7	ZONE 8	ZONE ID: ZONE 8 % CONT.: 30.
		ZONE 10 27. 27.
10	ZONE 28	ZONE ID: ZONE 28 % CONT.: 79.
		ZONE 28A 7. 6.
11	ZONE 7	ZONE ID: ZONE 7 % CONT.: 61.
		ZONE 8 23. 11.
12	ZONE 21	ZONE ID: ZONE 20 % CONT.: 39.
		ZONE 21 21. 20.
13	CZ 17	ZONE ID: CZ 17 % CONT.: 39.
		ZONE 8 28. 25.
		CZ 17 5.
		CZ 15 7.
		CZ 15 27. 12.
		CZ 15 3.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

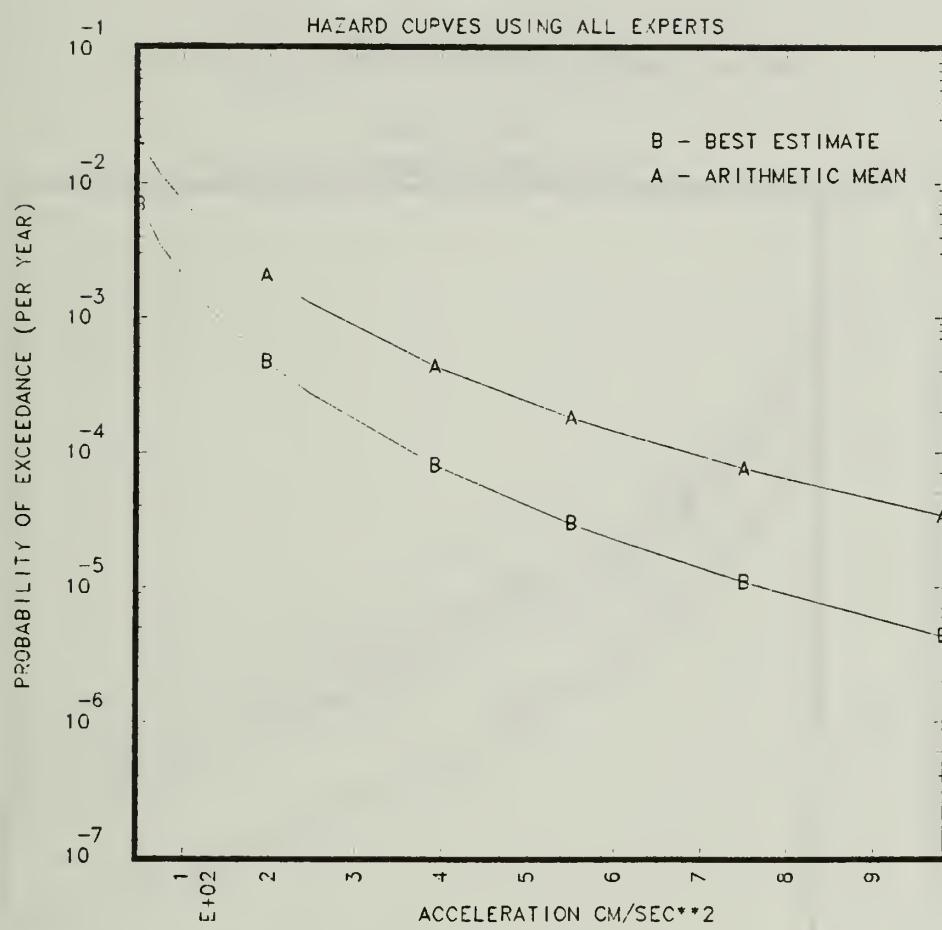


Figure 2.8.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the McGuire site.

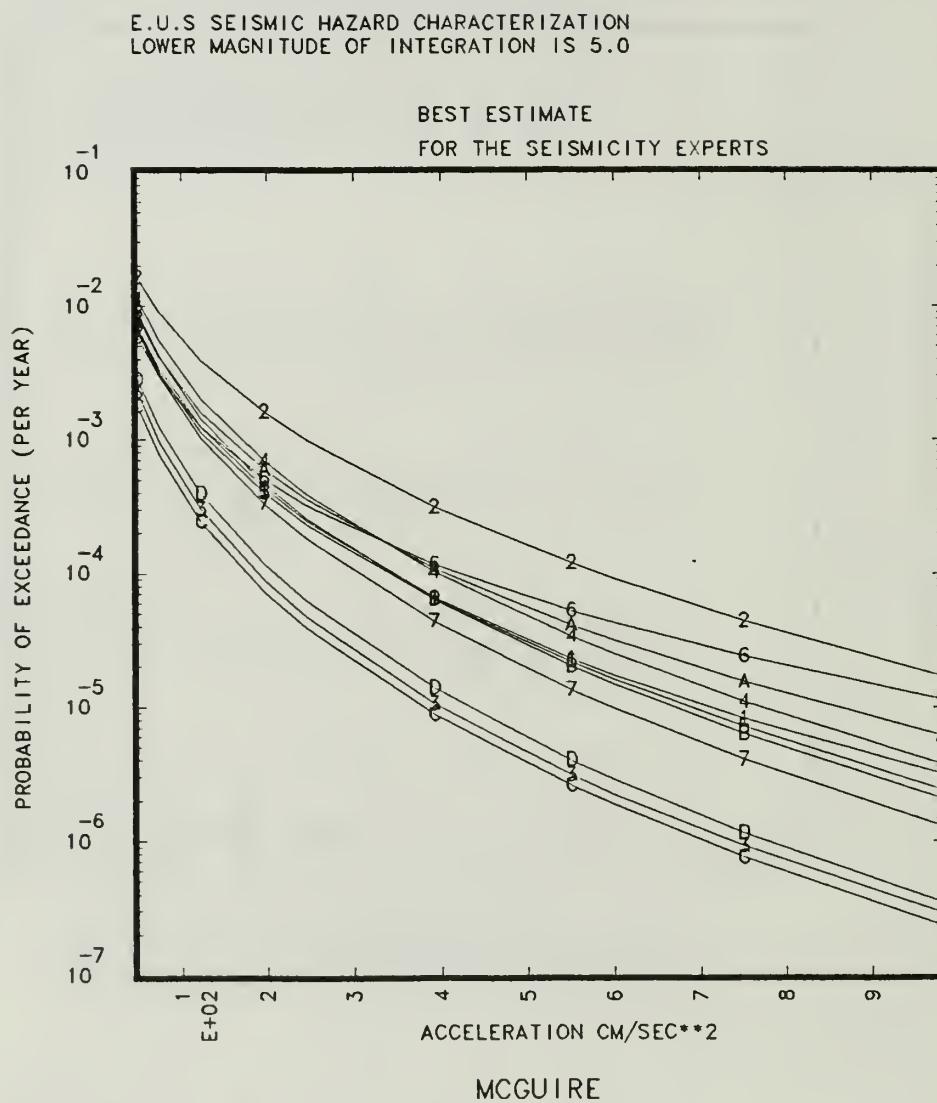


Figure 2.8.2 BEHCs per S-Expert combined over all G-Experts for the McGuire site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

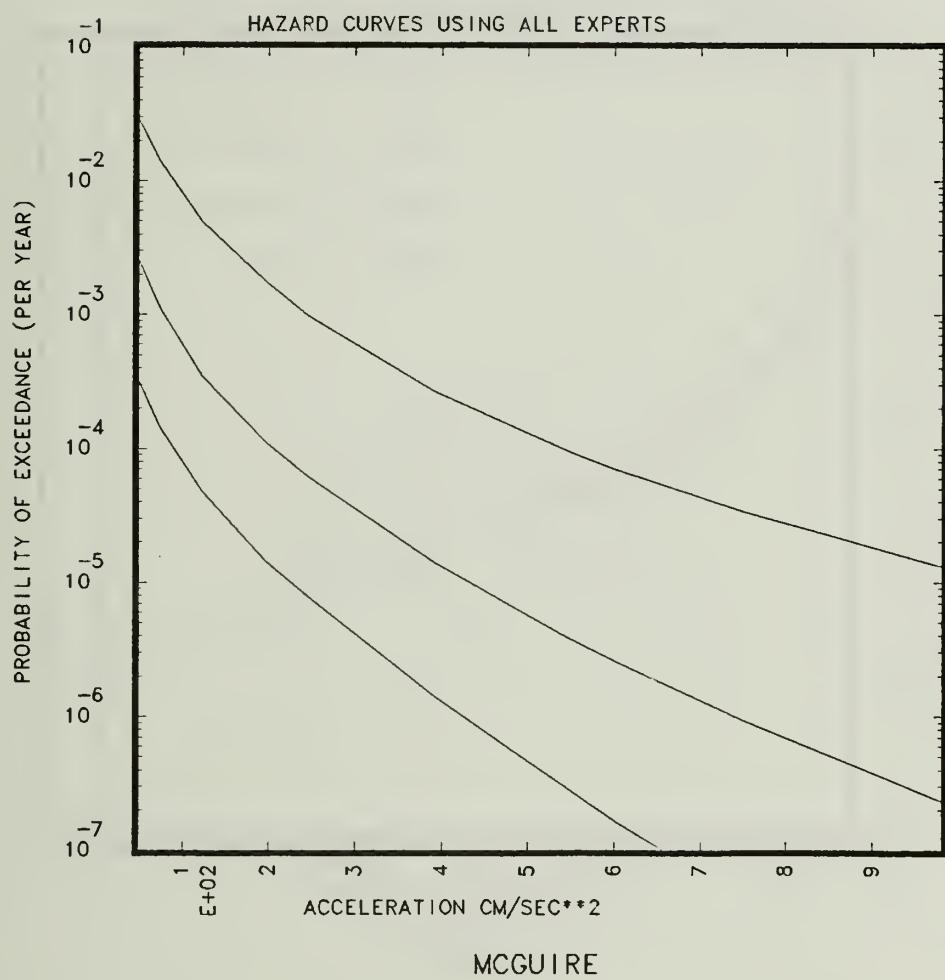


Figure 2.8.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the McGuire site.

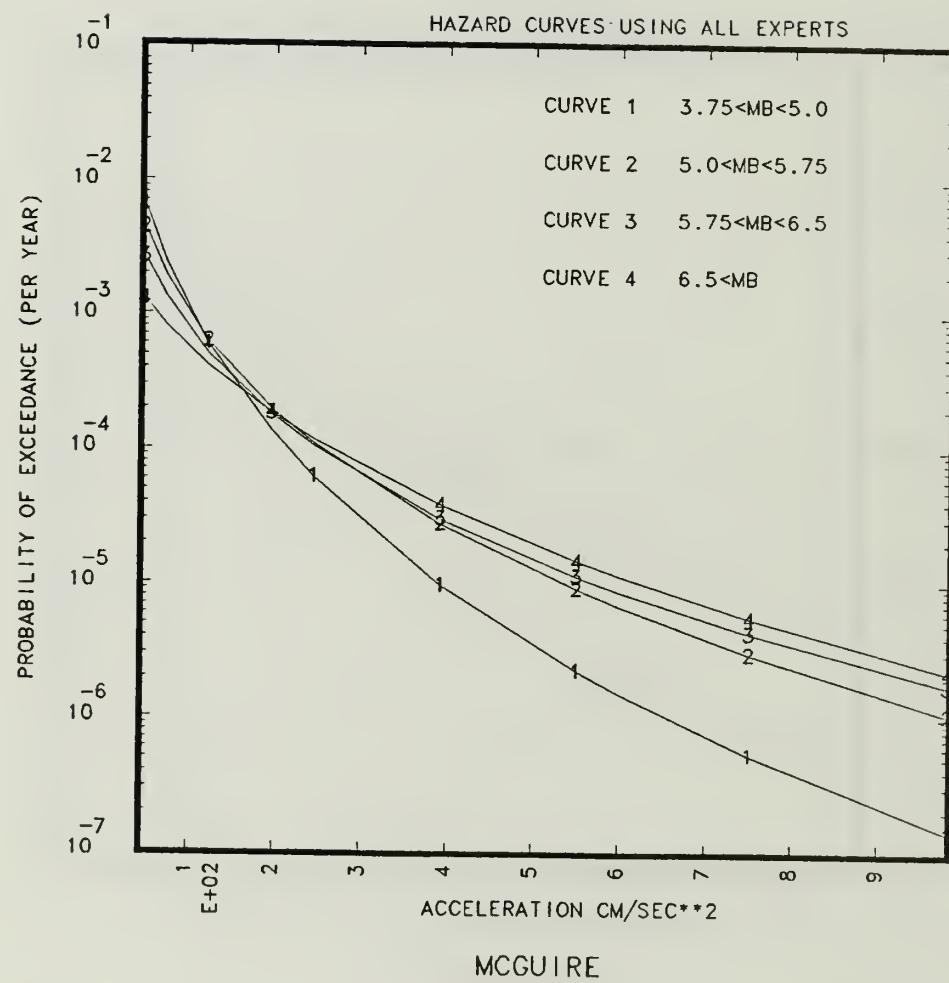


Figure 2.8.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the McGuire site.

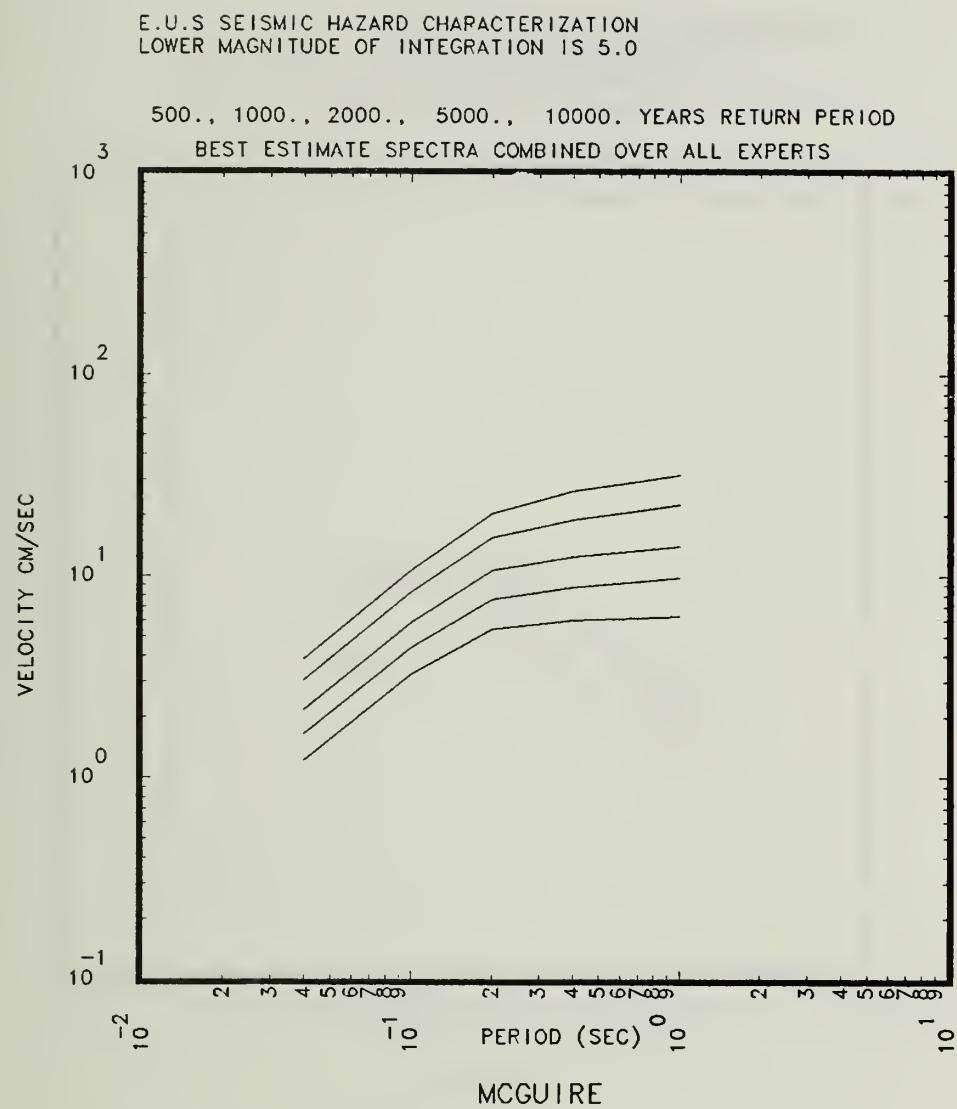


Figure 2.8.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the McGuire site.

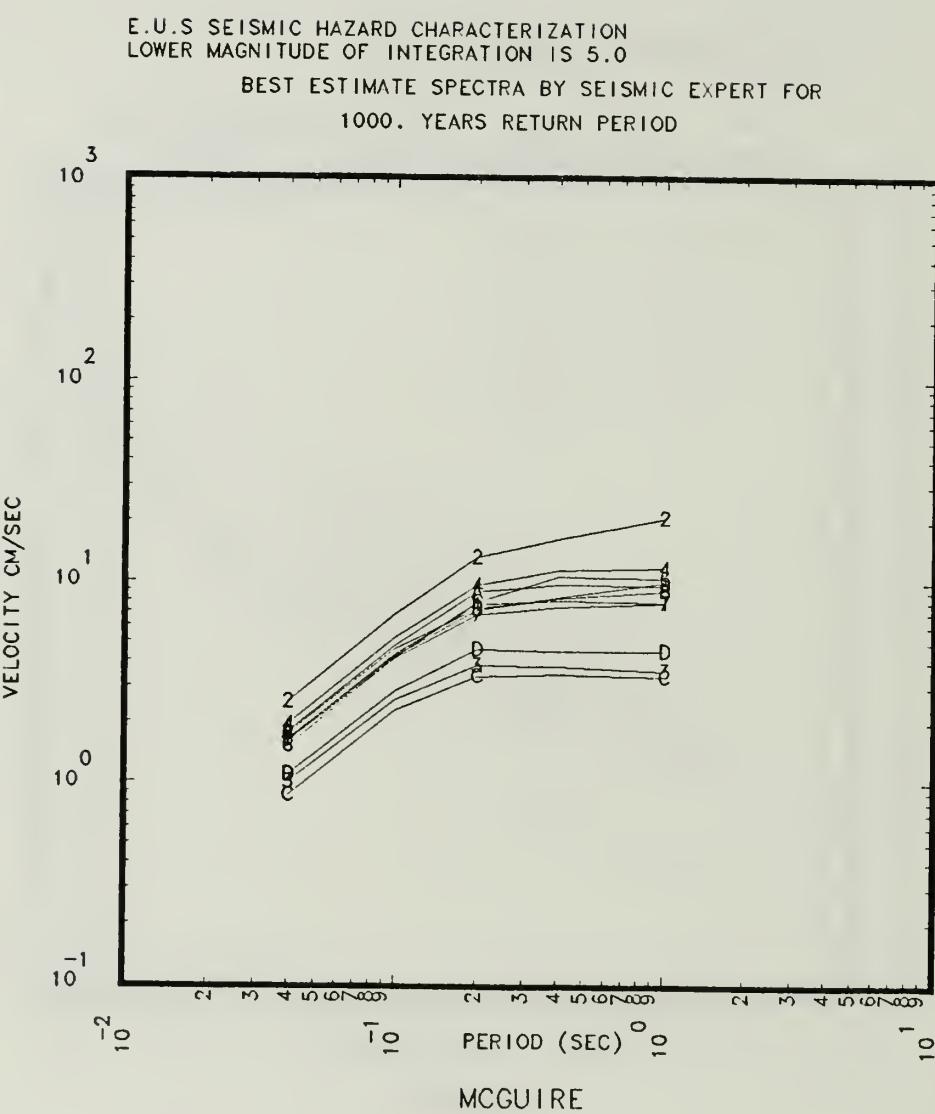


Figure 2.8.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the McGuire site. Plot symbols are given in Table 2.0.

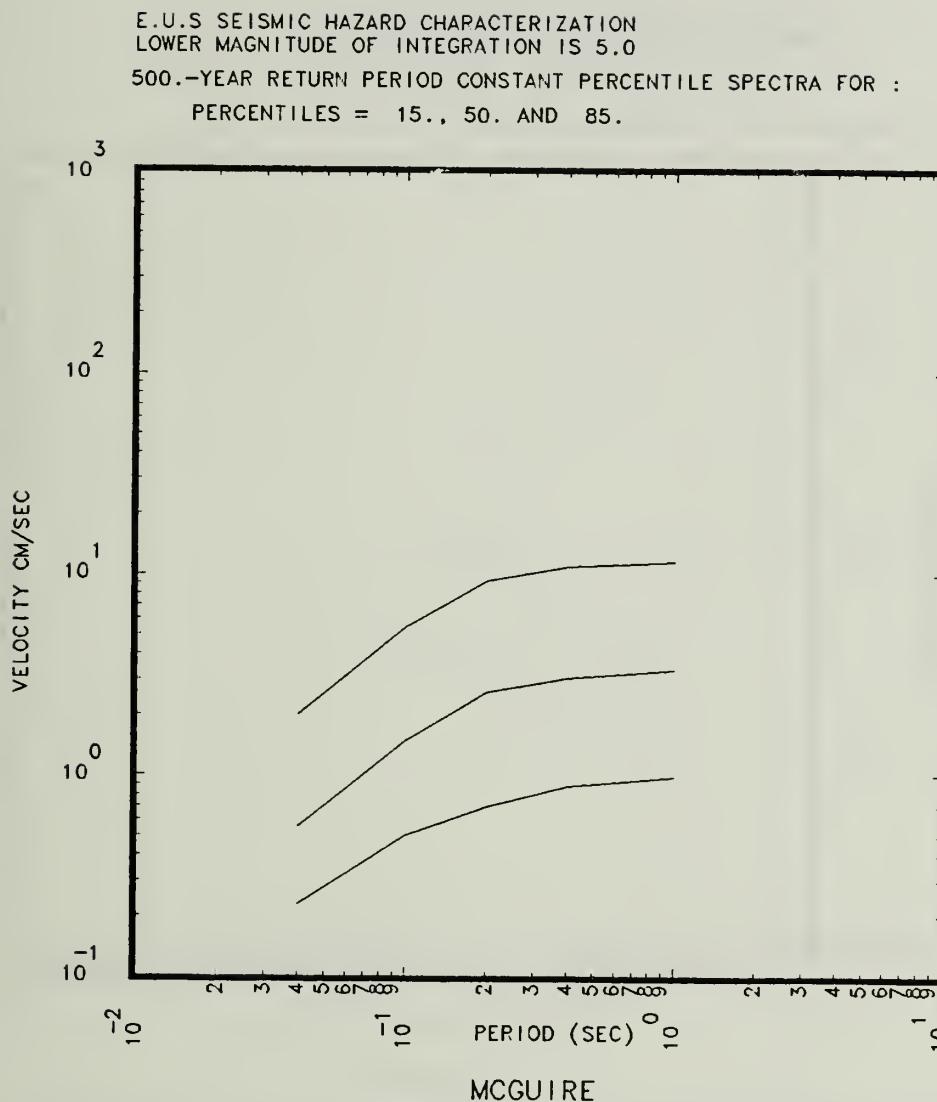


Figure 2.8.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the McGuire site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

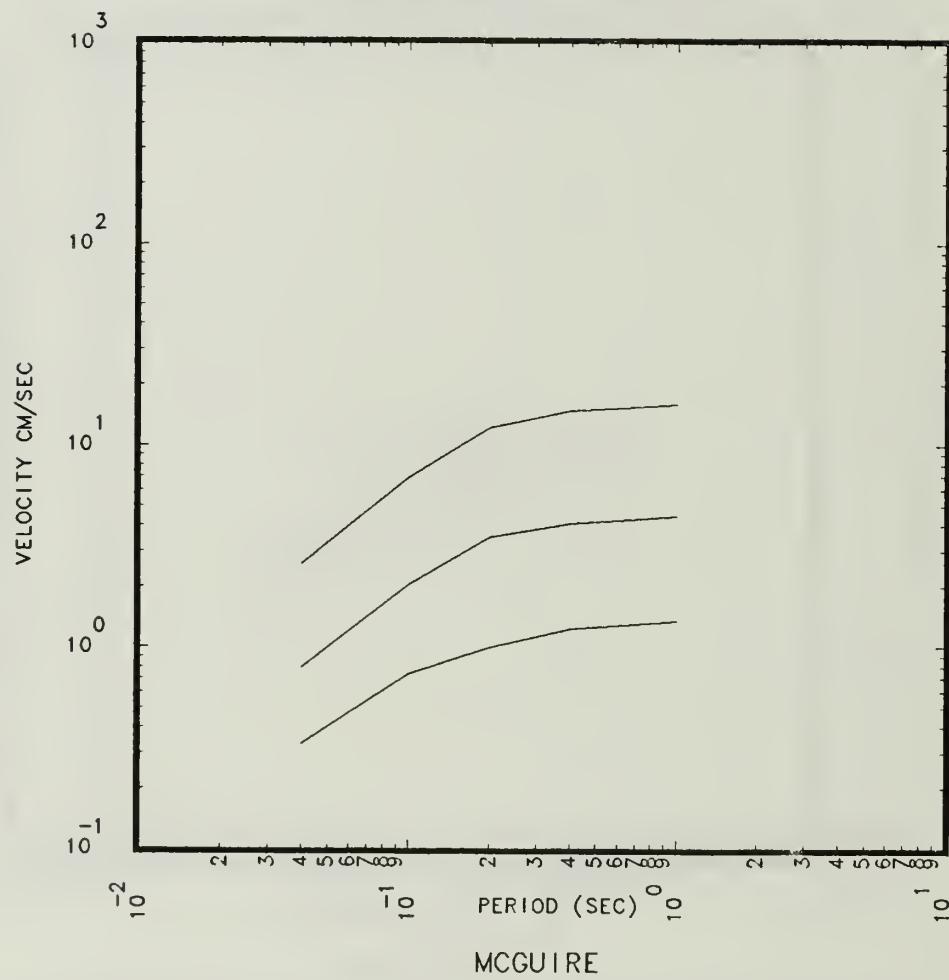


Figure 2.8.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the McGuire site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

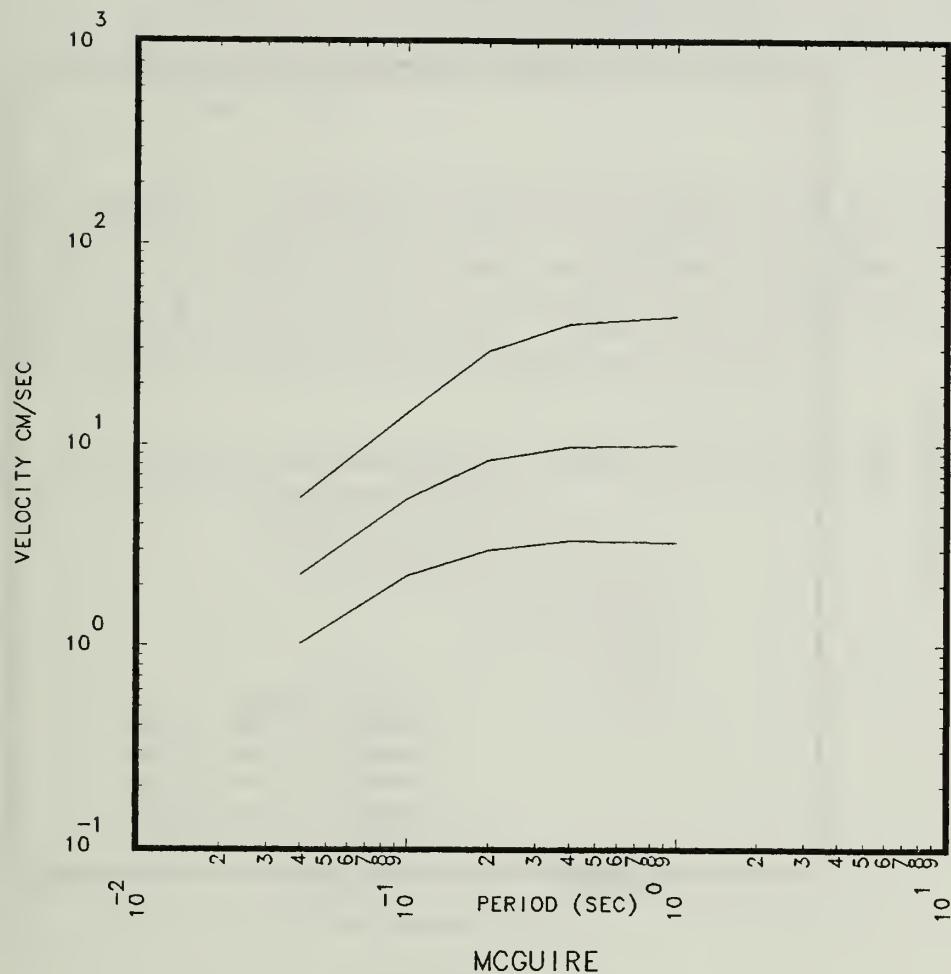


Figure 2.8.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the McGuire site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

50-TH PERCENTILE SPECTRA FOR ALL RETURN PERIODS

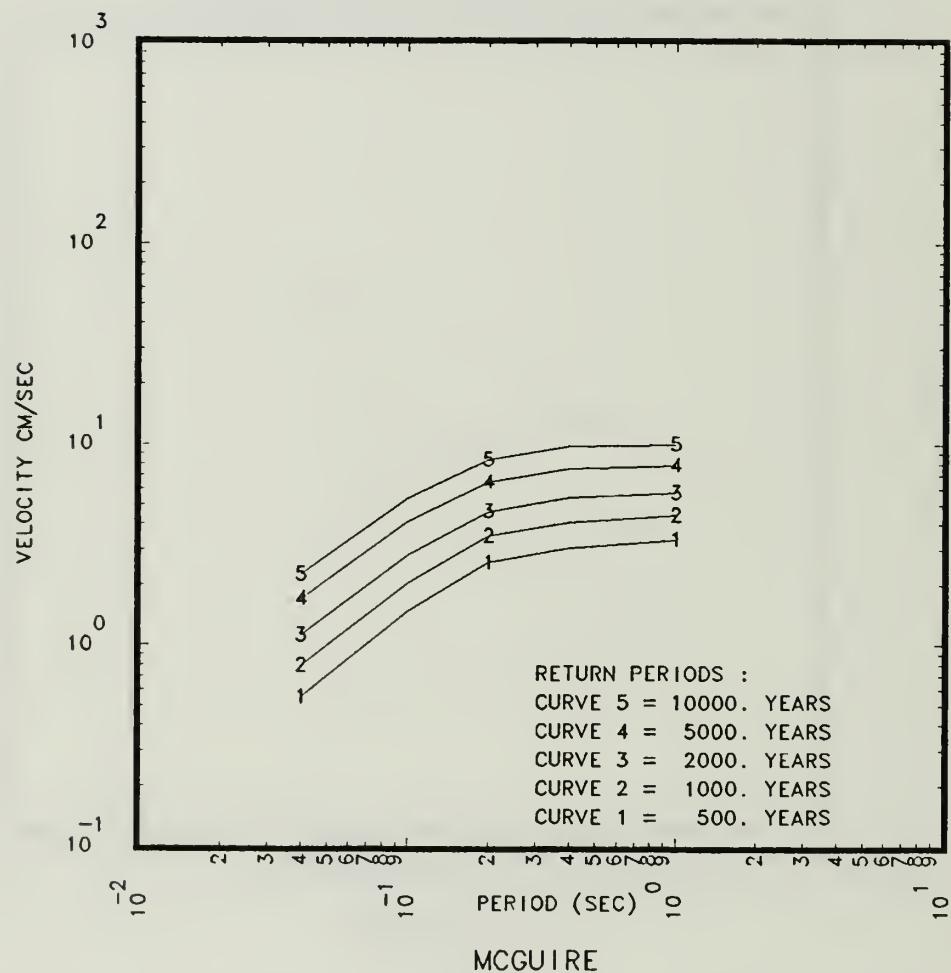


Figure 2.8.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the McGuire site.

2.9 NORTH ANNA

North Anna is a rock site represented by the symbol "9" on the location map in Fig. 1.1. Table 2.9.1 and Figs. 2.9.1 to 2.9.10 give the basic results for the North Anna site. The AMHC is close to the 85th percentile CPHC.

The spread between the individual S-Experts' BEHC shown in Fig. 2.9.4 is smaller than typical, indicating a relative convergence of opinions for this site.

Table 2.9.1 shows that for most S-Experts the large eastern seaboard (host) zones contribute the most to the hazard, with a significant contribution from the local Charleston area for S-Experts 4 and 5. Thus, it is not surprising that most of the hazard comes from distances smaller than 50 km, with almost no contribution from large earthquakes (greater than magnitude 6.5) at PGA values greater than about 0.3g.

Consequently, the small to moderate earthquakes (smaller than 6.5) contribute most to the hazard, as shown in Fig. 2.9.5. Furthermore, at PGA values less than about 0.2g, the contribution of small earthquakes (less than 5.0) is dominant, thus adding them to our results would increase the hazard significantly in that range of PGA values. Above 0.5g, the small earthquakes have insignificant contribution to the hazard at the site.

In addition to the above, all the typical comments for rock sites apply for North Anna rock site (see Section 2.1).

TABLE 2.9.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR NORTH ANNA

SITE SOIL CATEGORY ROCK

S-XPT NUM.	HOST ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT HIGH PGA(0.60G)
1	ZONE 3	ZONE ID: ZONE 3 % CONT.: 62.	ZONE 1 8. ZONE 2 3. ZONE 3 24. ZONE 4 8. ZONE 5 88. ZONE 6 7.
2	ZONE 27	ZONE ID: ZONE 27 % CONT.: 58.	ZONE 12. ZONE 28 COMP. ZON 26. ZONE 30 2. ZONE 27 27. ZONE 30 88. ZONE 28 9.
3	ZONE 6	ZONE ID: ZONE 6 % CONT.: 77.	ZONE 5 17. ZONE 8A 4. ZONE 9 1. ZONE 11 1. ZONE 10 26. ZONE 12 9.
4	ZONE 11	ZONE ID: ZONE 8 % CONT.: 31.	ZONE 11 30. ZONE 10 17. ZONE 12 5. ZONE 13 10. ZONE 14 10. ZONE 15 5.
5	ZONE 1	ZONE ID: ZONE 1 % CONT.: 42.	ZONE 9 34. ZONE 6 10. ZONE 10 5. ZONE 11 1. ZONE 12 61. ZONE 13 36.
6	ZONE 15	ZONE ID: ZONE 15 % CONT.: 73.	ZONE 13 12. ZONE 6 6. ZONE 11 5. ZONE 12 6. ZONE 13 9. ZONE 14 9.
7	ZONE 9	ZONE ID: ZONE 9 % CONT.: 55.	ZONE 7 28. ZONE 29 9. ZONE 10 6. ZONE 11 6. ZONE 12 5.
10	ZONE 4B	ZONE ID: ZONE 4B % CONT.: 57.	ZONE 5 30. ZONE 28A 6. ZONE 15 3. ZONE 16 5. ZONE 17 6. ZONE 18 6. ZONE 19 5.
11	ZONE 7	ZONE ID: ZONE 7 % CONT.: 45.	ZONE 5 28. ZONE 6 10. ZONE 8 10. ZONE 9 1. ZONE 10 1. ZONE 11 91.
12	ZONE 32	ZONE ID: ZONE 32 % CONT.: 88.	ZONE 20 5. ZONE 23A 3. ZONE 22 2. ZONE 32 99. ZONE 20 0. ZONE 23A 0.
13	CZ 17	CZ ID: CZ 17 % CONT.: 71.	CZ 8 14. CZ 15 9. CZ 17 5. CZ 18 9. CZ 19 5.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

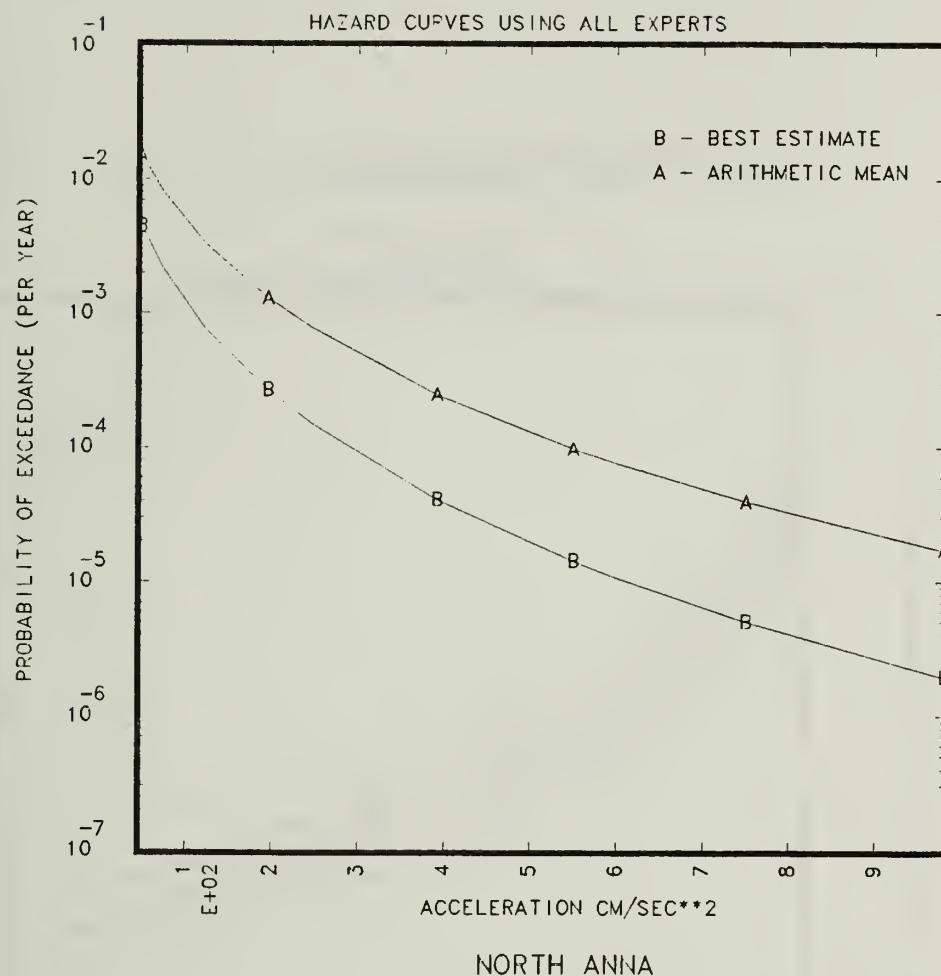


Figure 2.9.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the North Anna site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

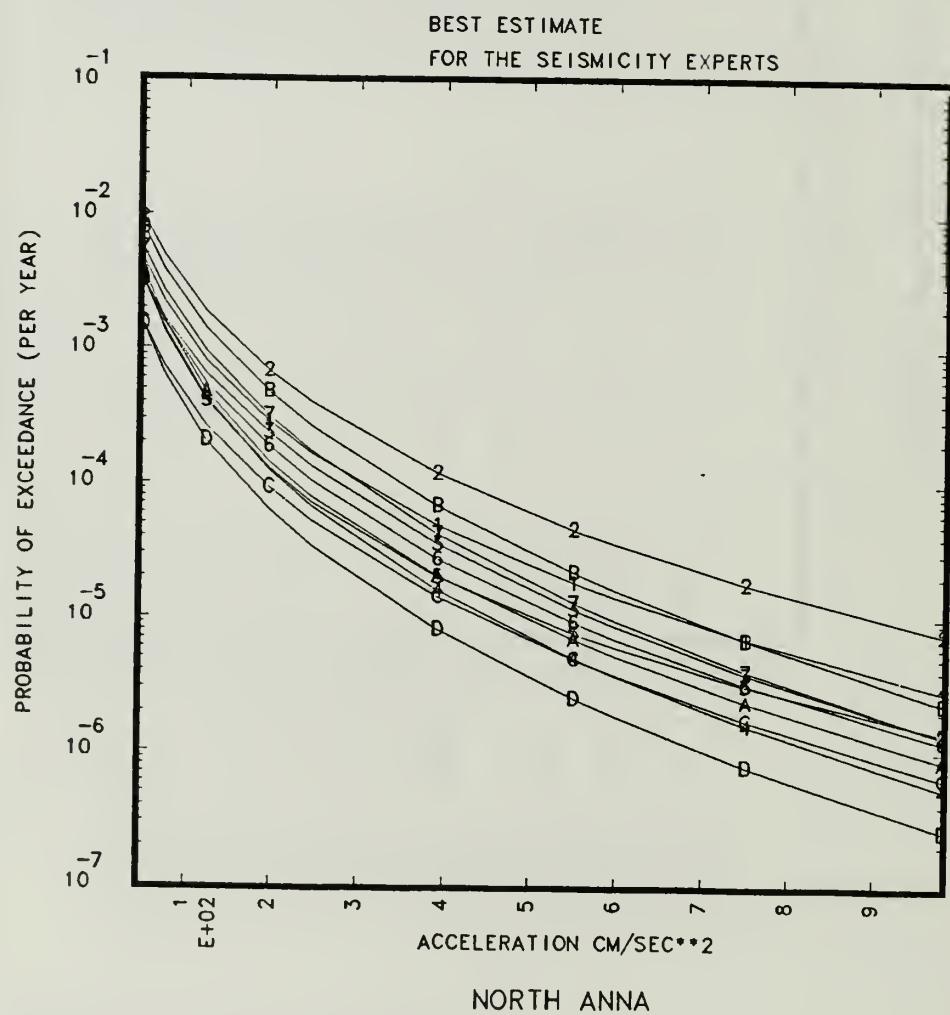


Figure 2.9.2 BEHCs per S-Expert combined over all G-Experts for the North Anna site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

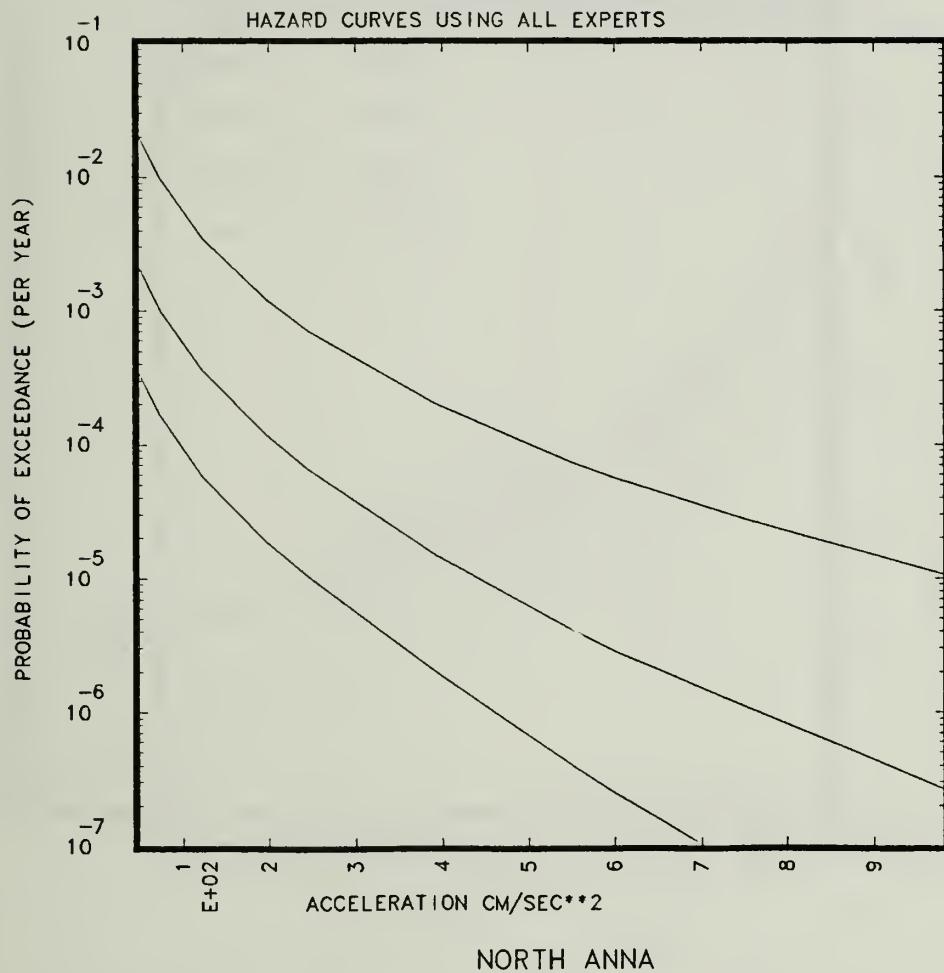


Figure 2.9.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the North Anna site.

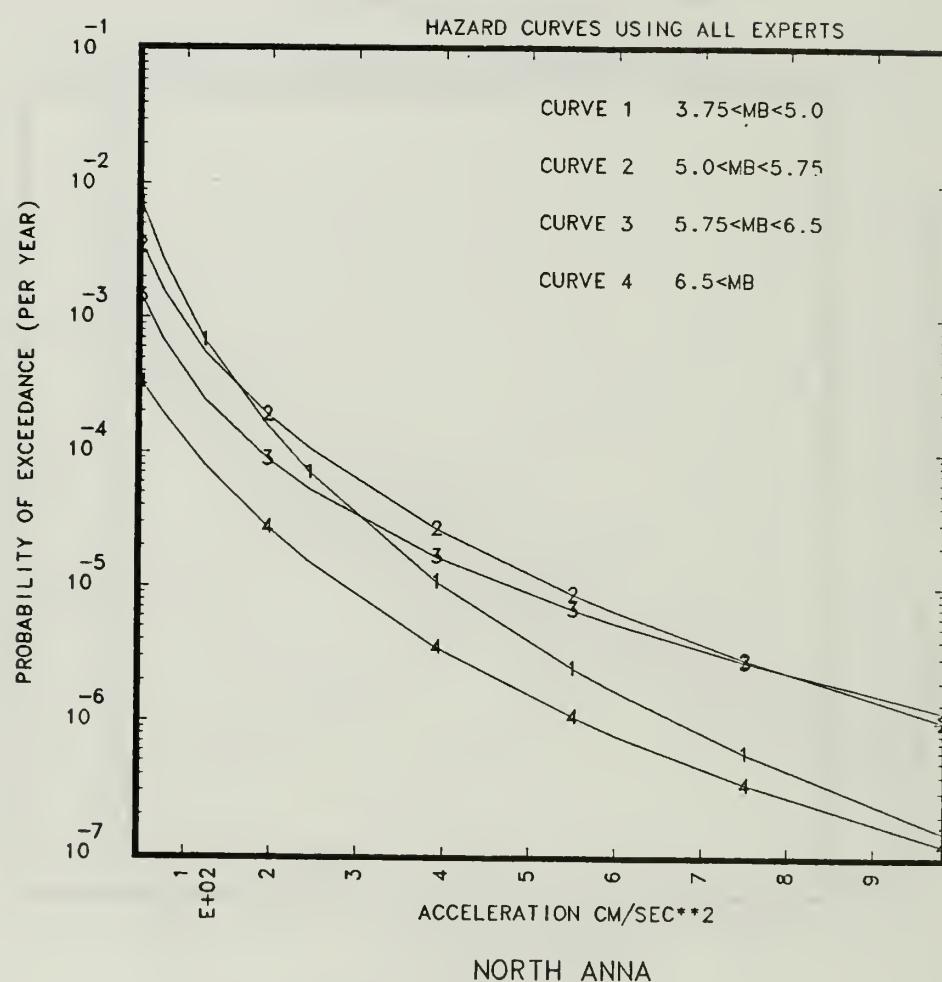


Figure 2.9.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the North Anna site.

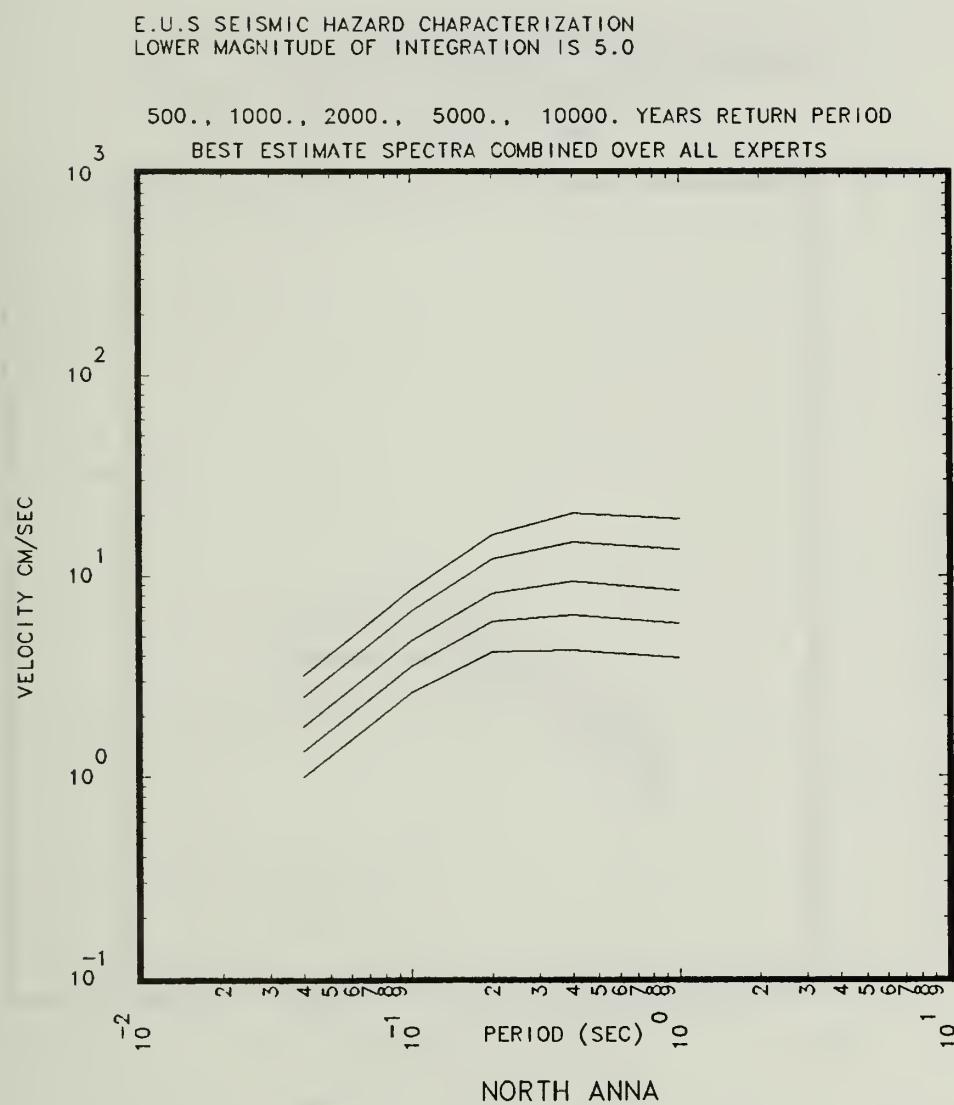


Figure 2.9.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the North Anna site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

BEST ESTIMATE SPECTRA BY SEISMIC EXPERT FOR
1000. YEARS RETURN PERIOD

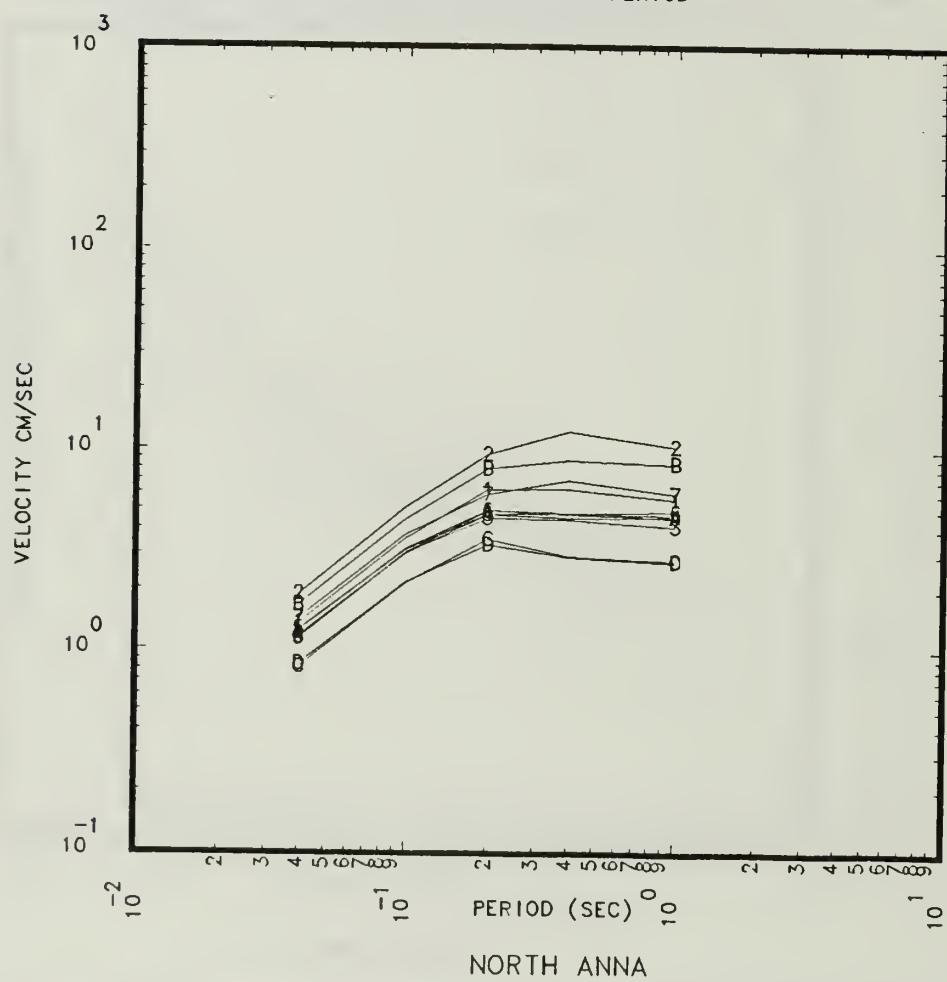


Figure 2.9.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the North Anna site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

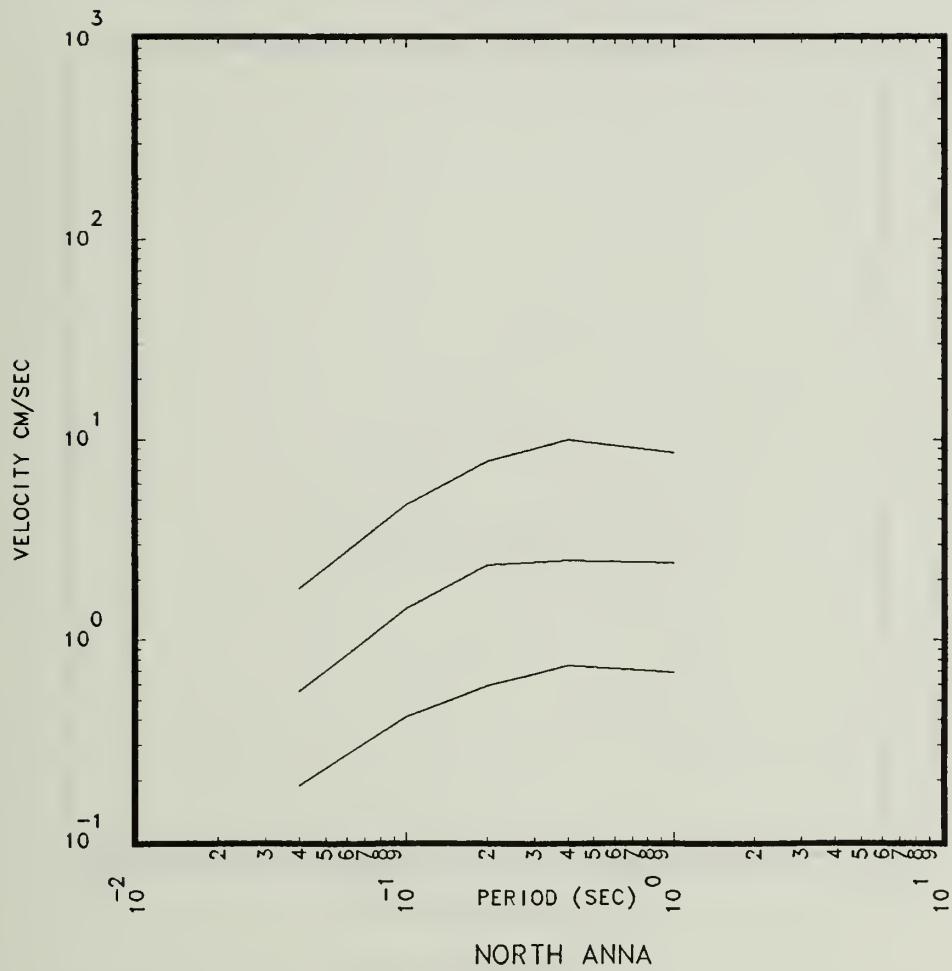


Figure 2.9.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the North Anna site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

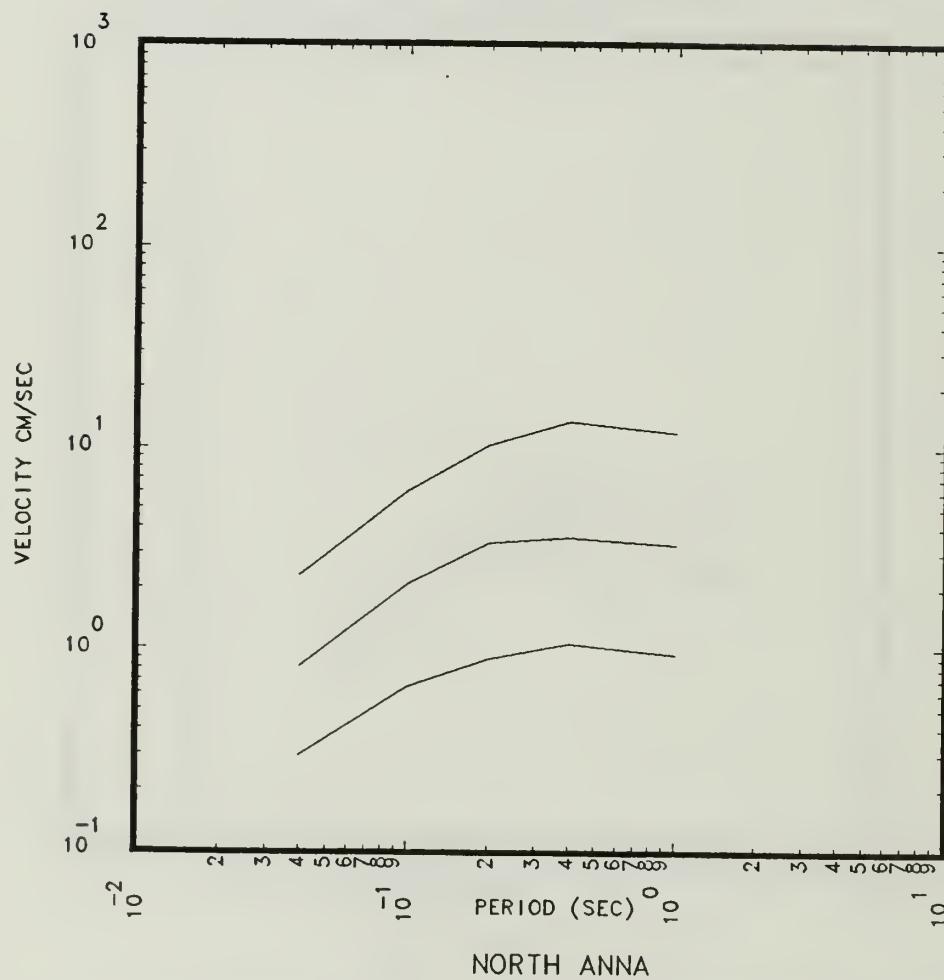


Figure 2.9.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the North Anna site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

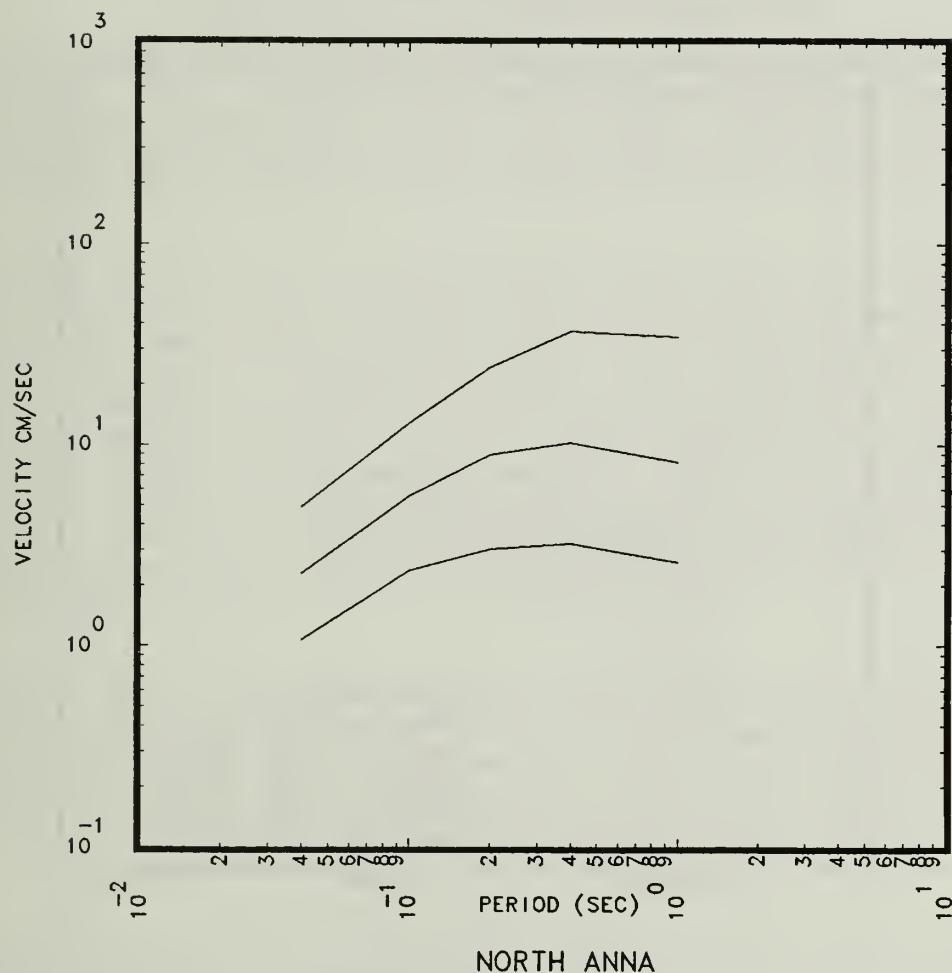


Figure 2.9.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the North Anna site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

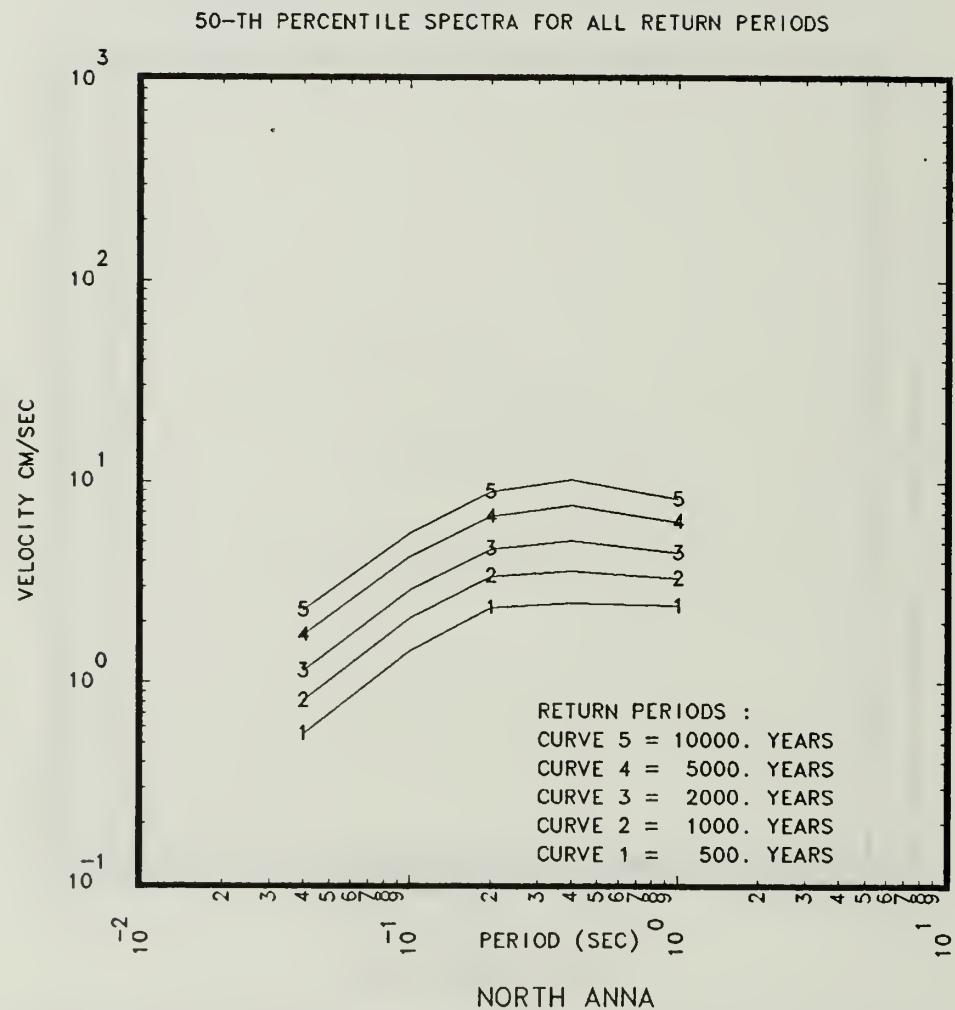


Figure 2.9.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the North Anna site.

2.10 OCONEE

Oconee is a rock site represented by the symbol "A" on the location map in Fig. 1.1. Table 2.10.1 and Figs. 2.10.1 to 2.10.10 give the basic results for the Oconee site.

The AMHC (Fig. 2.10.1) is much higher than the 85th percentile CPHC (Fig. 2.10.3), indicating the presence of outliers in the sample set of hazard curves generated in the Monte Carlo simulation (see Vol. I, Section 2.3).

The spread of the BEHC displayed in Fig. 2.10.2 indicating the diversity of opinion of the experts is typical for region 2 (southeast).

Figure 2.10.4 shows that the small earthquakes dominate the hazard below PGA values of 0.15g. At 0.1g including the small earthquakes (between magnitude 3.75 and 5.0) would approximately double the hazard. Figure 2.10.4 also shows that above 0.15g the earthquakes in the three ranges above magnitude 5.0 contribute approximately equally to the hazard.

Oconee is centrally located in the southeast, with respect to the seismic zonation. Table 2.10.1 shows that both the Charleston and the New Madrid areas contribute significantly to the hazard. This is due in part to the low attenuation of G-Expert 5's GM model for rock sites, as explained in Section 2.1. However, the Oconee site is located sufficiently far from the localized areas of high seismicity and high upper magnitude cutoff identified by most S-Expert around Charleston and New Madrid, that nearby earthquakes seismic located in zones surrounding the site also play an important role. This is seen in Table 2.10.1 by the rather low percentage numbers for the first dominant zones and the relatively uniform distribution of these percentages among all zones.

Figure 2.10.11 shows a segregation of hazard contribution per distance ranges. The relatively small spread in Fig. 2.10.11 shows that although the distant earthquakes (more than 150 km) and the remaining earthquakes all contribute significantly to the hazard except at small PGA values (less than about 0.2g). The nearby earthquakes almost do not have any effect on the hazard.

In addition to the above, all the typical comments for rock sites given in Section 2.1 apply for the Oconee rock site.

TABLE 2.10.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR ZONE

SITE SOIL CATEGORY ROCK

S-XPT HOST NUM. ZONE	HOST ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)
1 ZONE 3	% CONT: 39.	ZONE 3, ZONE 4, ZONE 9, ZONE 21, ZONE 21.
2 ZONE 27	% CONT: 39.	ZONE 18, ZONE 27, ZONE 29, ZONE 29, ZONE 29.
3 ZONE 7	% CONT: 39.	ZONE 5, ZONE 9, ZONE 13, ZONE 7, ZONE 5.
4 ZONE 9	% CONT: 37.	ZONE 4, ZONE 10, ZONE 28, ZONE 9, ZONE 9.
5 ZONE 11	% CONT: 37.	ZONE 9, ZONE 11, ZONE 15, ZONE 10, ZONE 10.
6 ZONE 11	% CONT: 44.	ZONE 13, ZONE 11, ZONE 11, ZONE 16, ZONE 16.
7 ZONE 8	% CONT: 58.	ZONE 13, ZONE 17, ZONE 18, ZONE 13, ZONE 11, ZONE 15, ZONE 10.
10 ZONE 28	% CONT: 43.	ZONE 6, ZONE 7, ZONE 8, ZONE 10, ZONE 6, ZONE 7, ZONE 8, ZONE 10.
11 ZONE 7	% CONT: 88.	ZONE 15, ZONE 12A, ZONE 28A, ZONE 16, ZONE 16, ZONE 22, ZONE 22.
12 ZONE 21	% CONT: 31.	ZONE 8, ZONE 4, ZONE 11, ZONE 99, ZONE 28, ZONE 15, ZONE 19 = ZONE 12A, ZONE 1.
13 CZ 17	% CONT: 51.	CZ 17, CZ 17, ZONE 5, ZONE 9, ZONE 13, ZONE 5, ZONE 8, CZ 17, ZONE 9, ZONE 56, ZONE 31, ZONE 8, ZONE 6.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

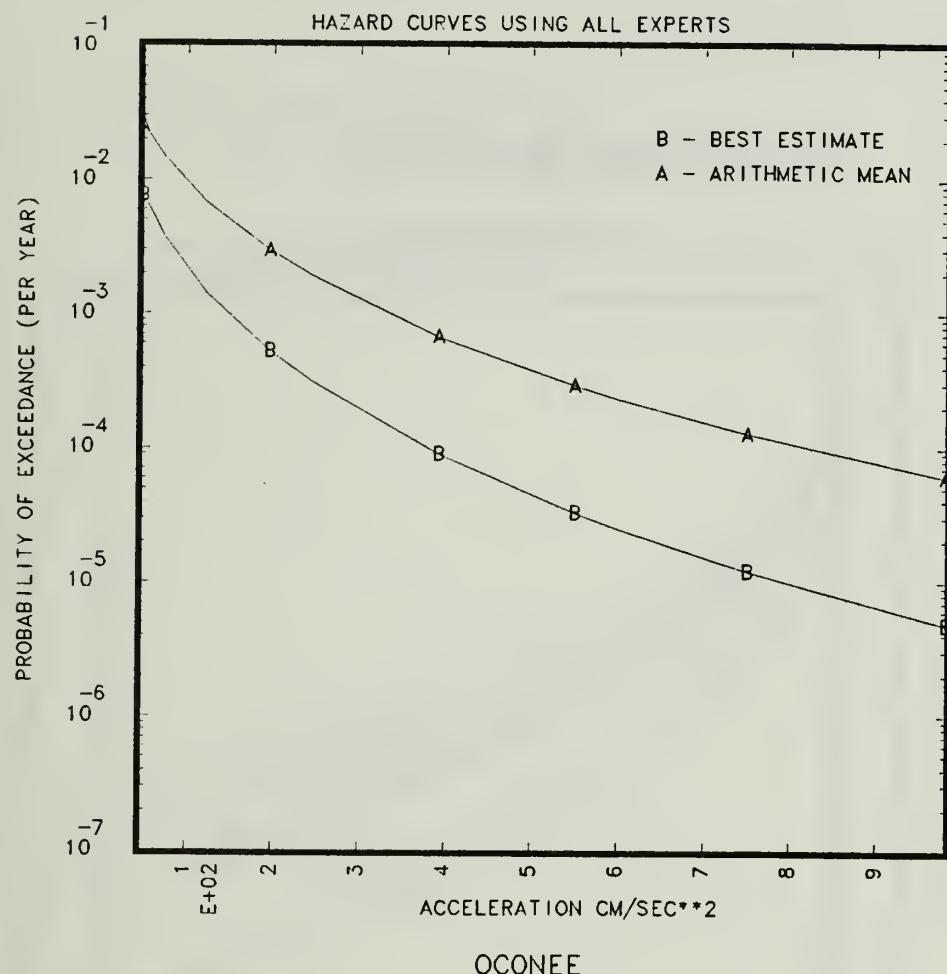


Figure 2.10.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Oconee site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

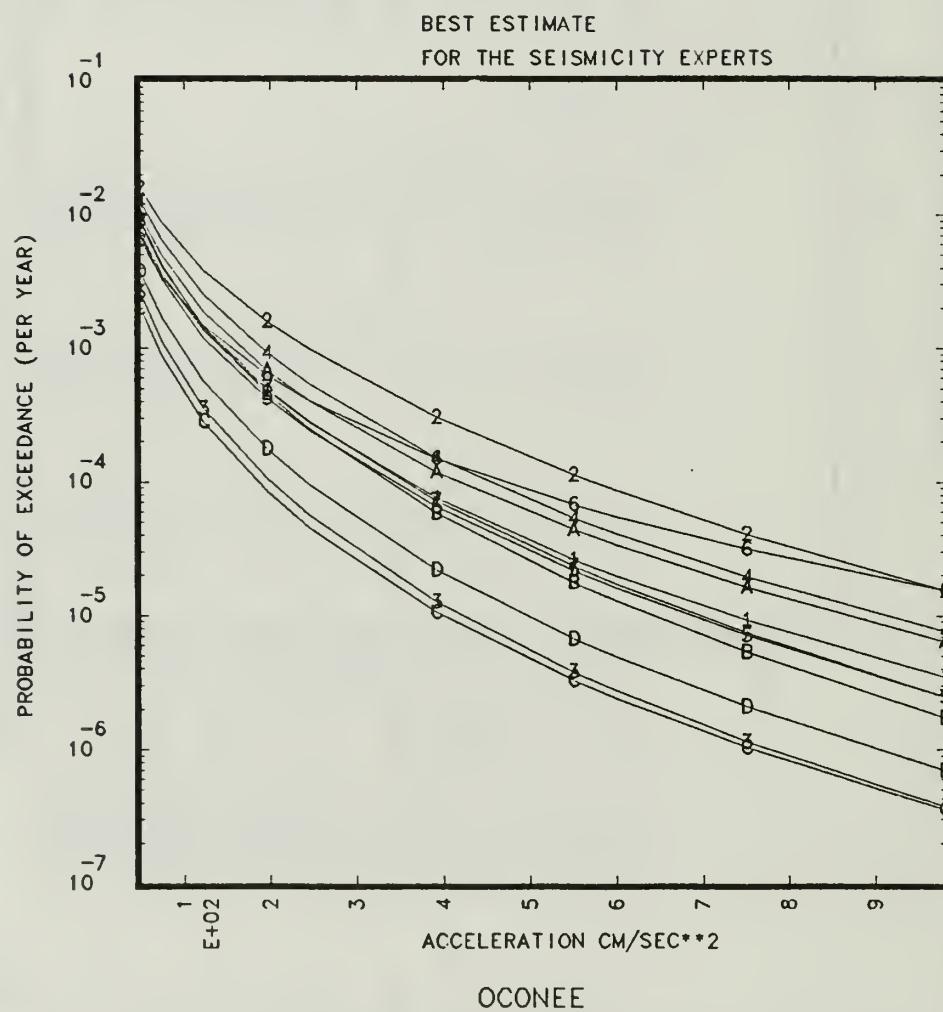


Figure 2.10.2 BEHCs per S-Expert combined over all G-Experts for the Oconee site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

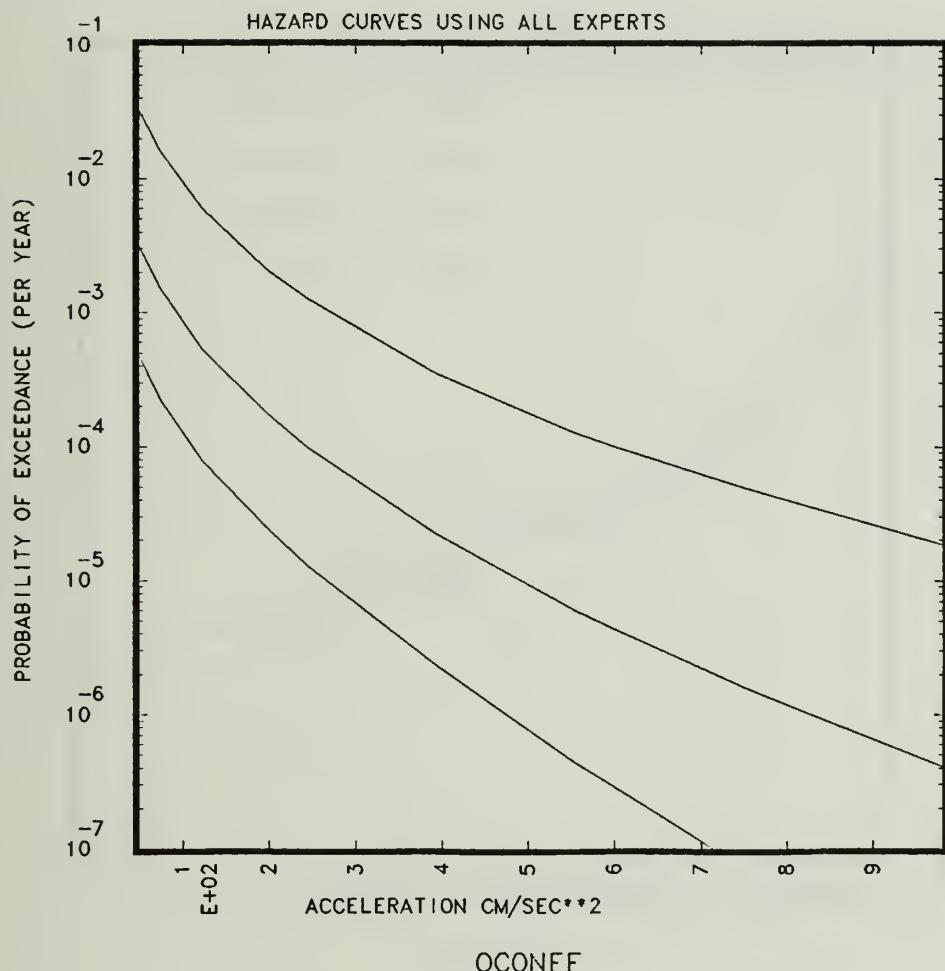


Figure 2.10.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Oconee site.

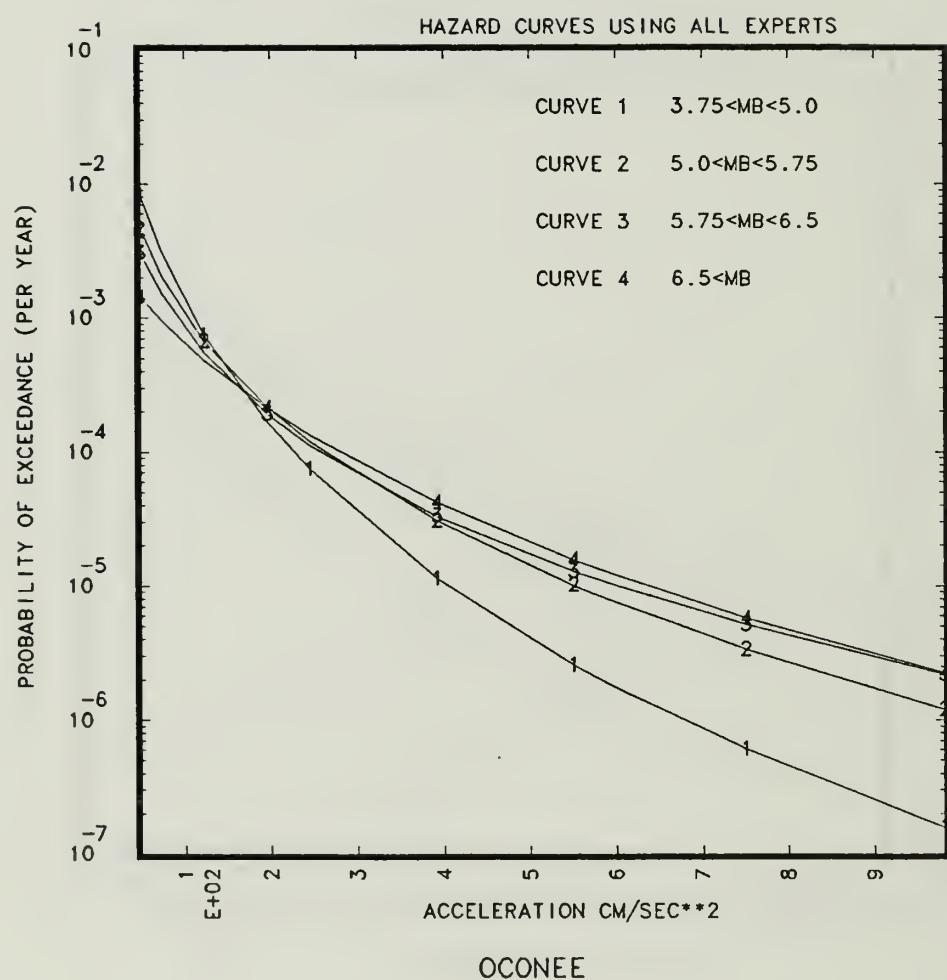


Figure 2.10.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Oconee site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

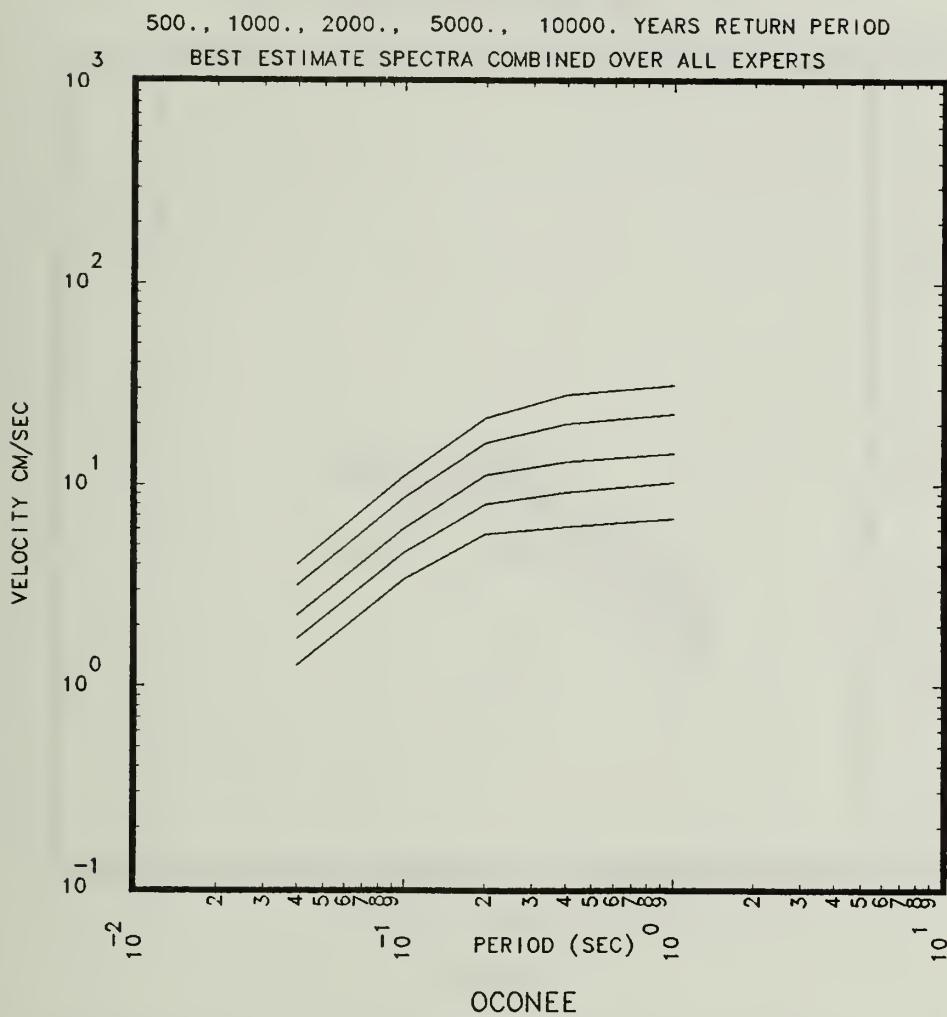


Figure 2.10.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Oconee site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
BEST ESTIMATE SPECTRA BY SEISMIC EXPERT FOR
1000. YEARS RETURN PERIOD

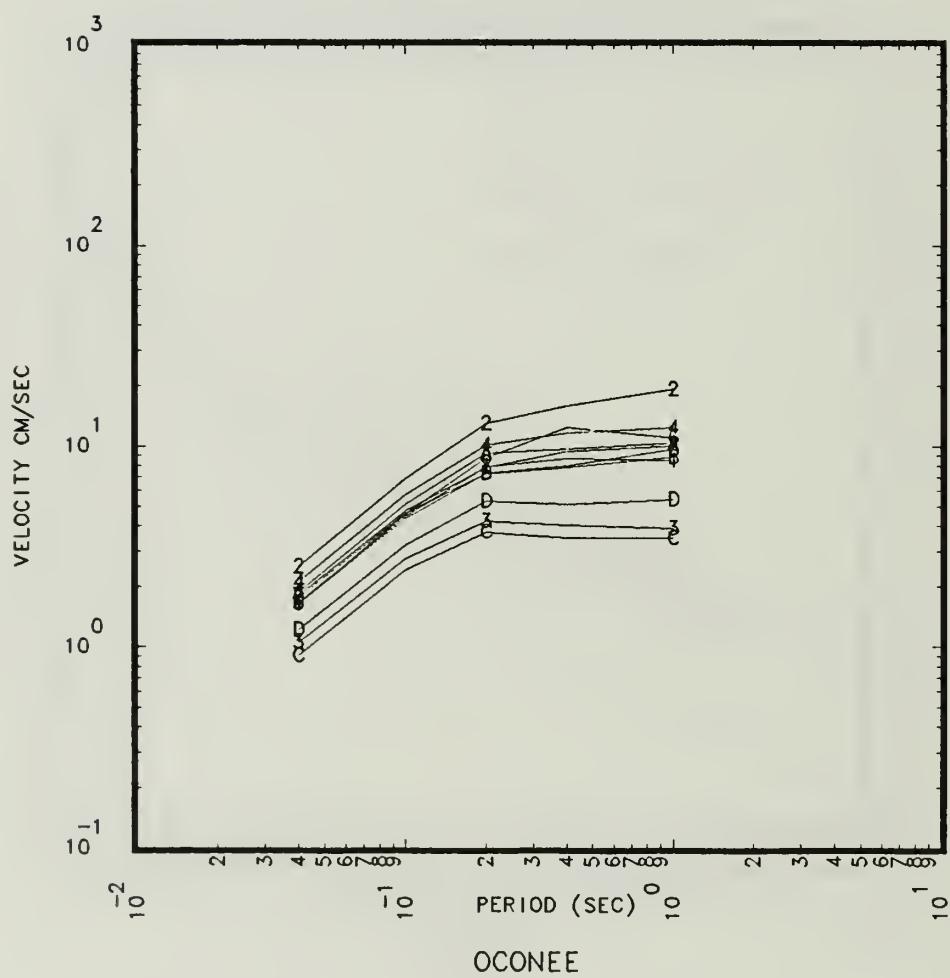


Figure 2.10.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Oconee site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

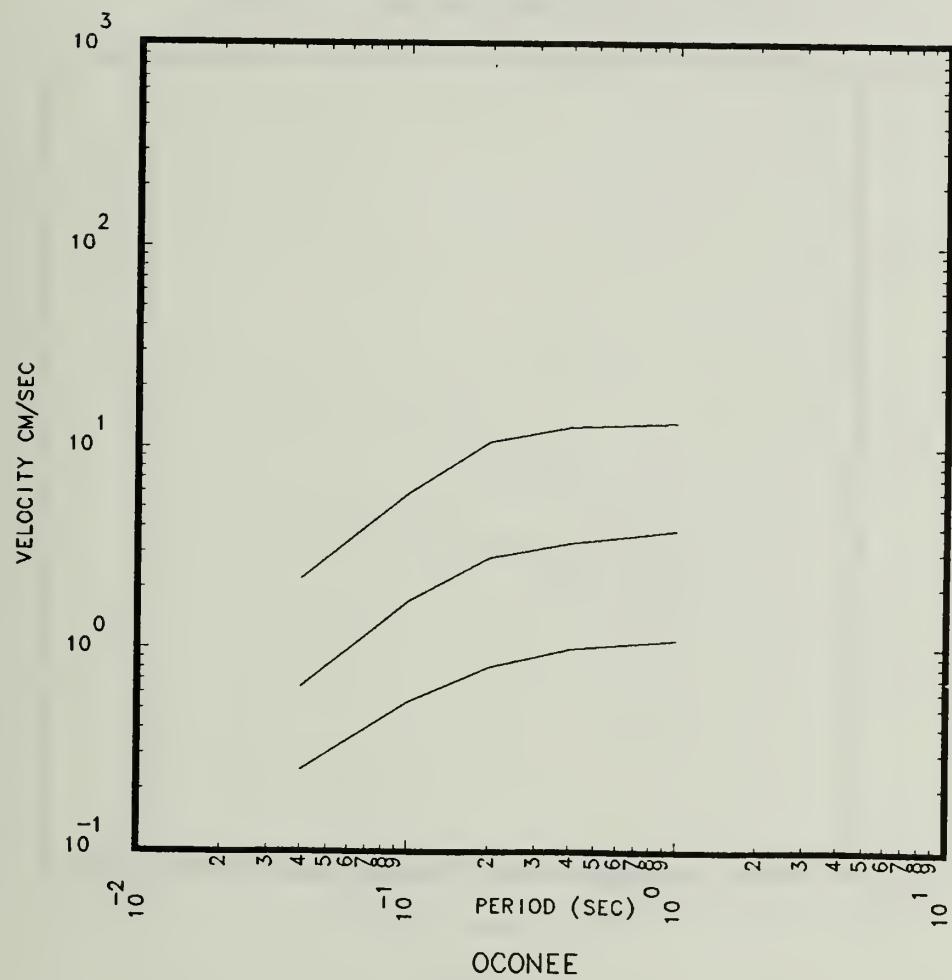


figure 2.10.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Oconee site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

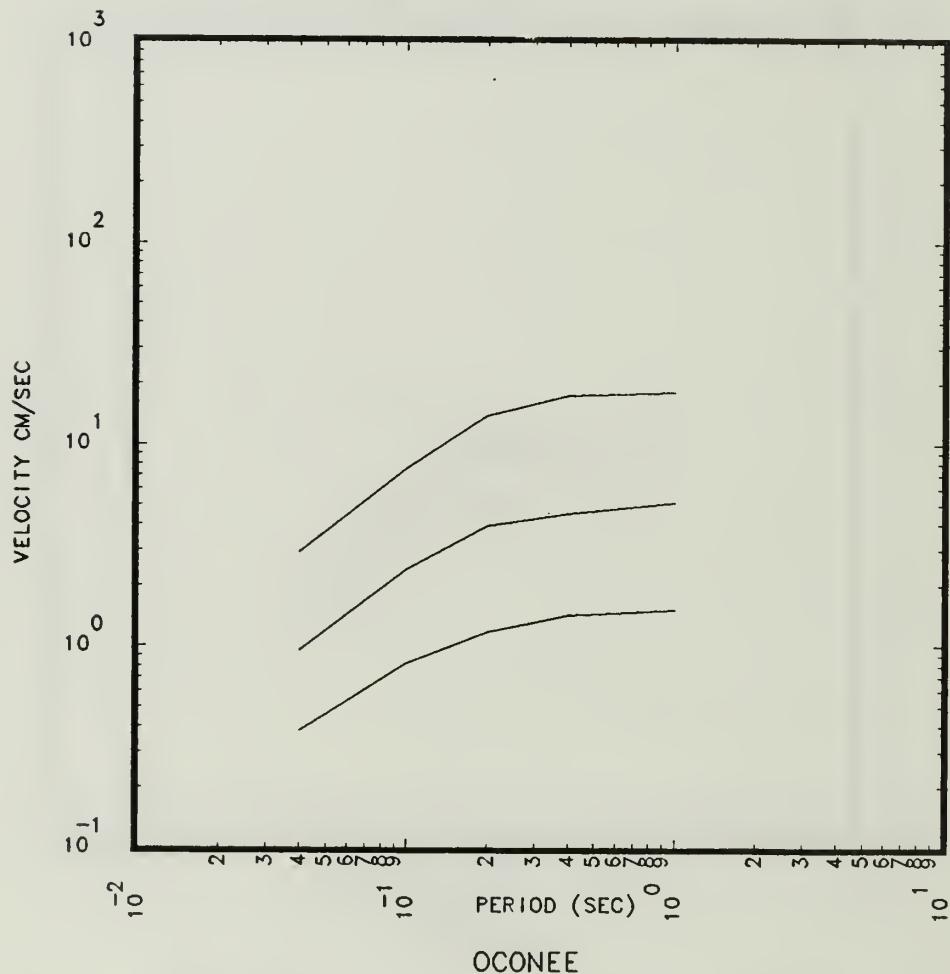


Figure 2.10.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Oconee site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

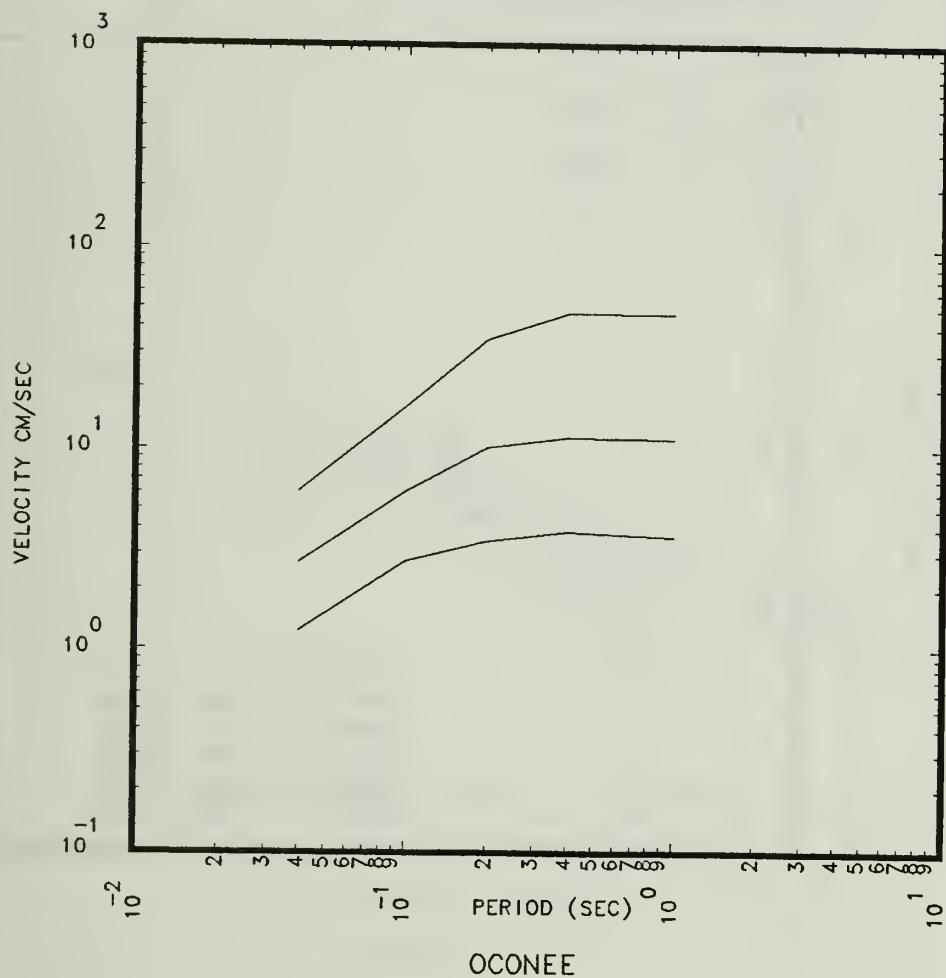


figure 2.10.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Oconee site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

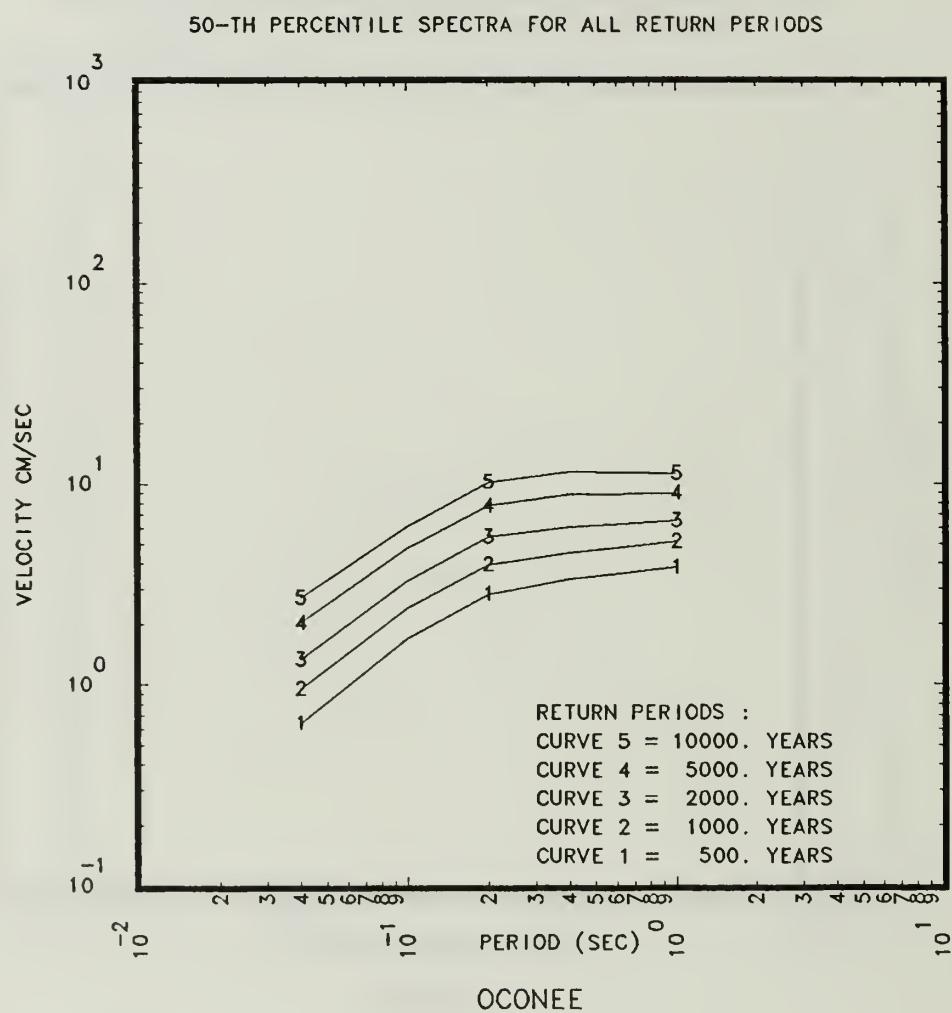


Figure 2.10.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Oconee site.

CONTRIBUTION TO THE HAZARD FOR PGA
FROM THE EARTHQUAKES IN 4 DISTANCE RANGES

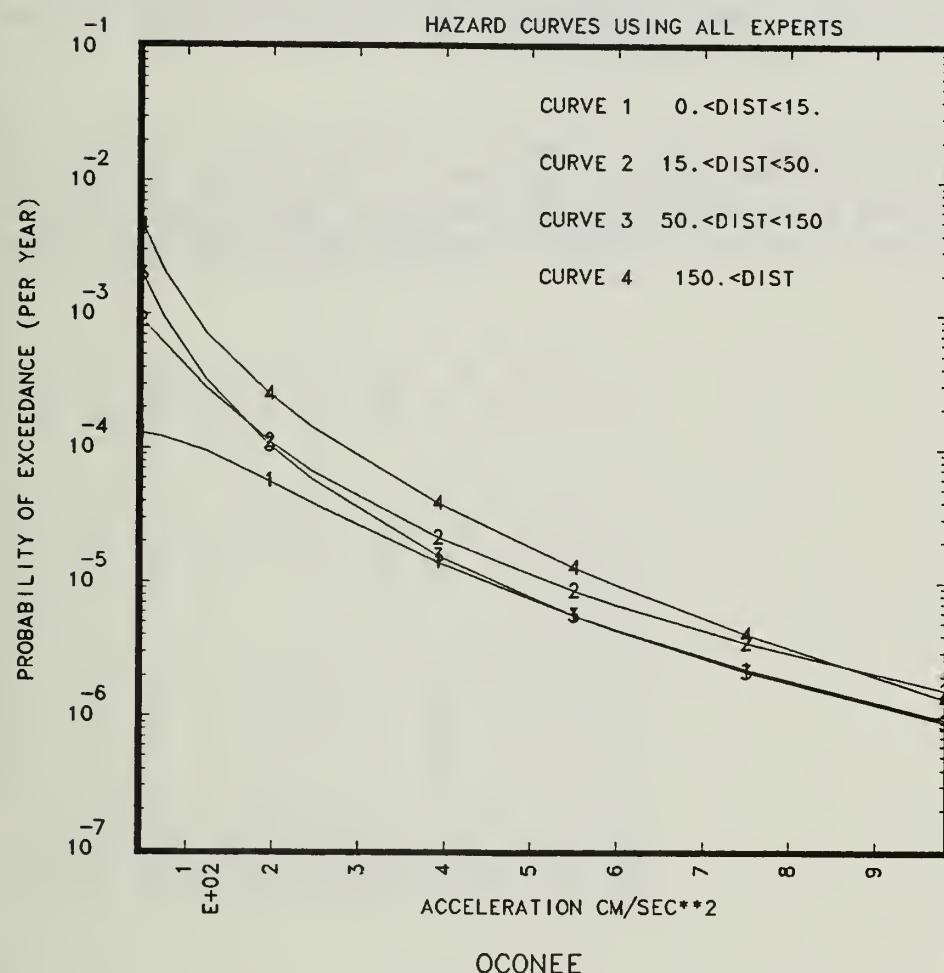


Figure 2.10.11 Contribution to the hazard from earthquakes segregated into four distance ranges, for the Oconee site, in terms of probability of exceedance of the PGA.

2.11 ROBINSON

Robinson was categorized as deep soil site and is represented by the symbol "B" on the location map in Fig. 1.1. Table 2.11.1 and Figs. 2.11.1 to 2.11.10 give the basic results for the Robinson site.

The AMHC is located much higher than the 85th percentile CPHC indicating the presence of outliers in the sample set of the hazard curves generated in the Monte Carlo simulation (see Vol. I, Section 2.3).

For this site the Charleston area plays an important role since it is relatively close. Table 2.11.1 shows that for most S-Experts, the Charleston seismic zone dominate the hazard.

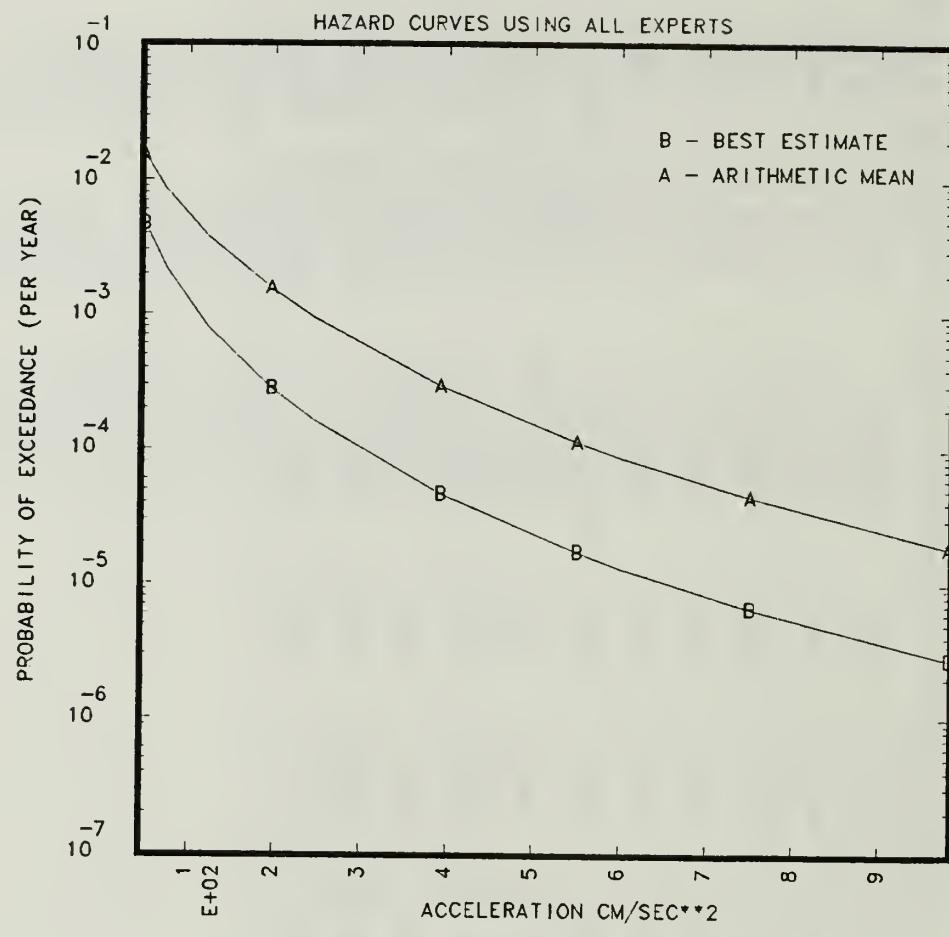
Figure 2.11.2 shows a large spread in the BEHC for all S-Experts, which is mostly due to the diversity of opinions in the modeling of the Charleston area. Figure 2.11.4 confirms that the hazard at the deep soil Robinson site is dominated by medium to large earthquakes mostly from the Charleston area.

MOST IMPORTANT ZONES PER S-EXPERT
FOR ROBINSON

SITE SOIL CATEGORY DEEP-SOIL

S-XPT NUM.	HOST ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND AT LOW PGA(0.125G) % OF CONTRIBUTION	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND AT HIGH PGA(0.60G)
1	ZONE 1 % CONT:	ZONE 2 50. 26.	ZONE 3 19. 52.
2	ZONE 29 % CONT:	ZONE 30 76. 21.	ZONE 29 27. 78.
3	ZONE 8 % CONT:	ZONE 9 56. 27.	ZONE 8A 11. 5.
4	ZONE 10 % CONT:	ZONE 10 96. 4.	ZONE 4 0.
5	ZONE 10 % CONT:	ZONE 9 87. 11.	ZONE 8 15. 1.
6	ZONE 13 % CONT:	ZONE 13 99. 1.	ZONE 11 COMP ZONE 18 0.
7	ZONE 8 % CONT:	ZONE 10 56. 33.	ZONE 8 6. 10.
10	ZONE 4B % CONT:	ZONE 4B 49. 41.	ZONE 7 1. 1.
11	ZONE 7 % CONT:	ZONE 8 65. 34.	ZONE 9 9. 0.
12	ZONE 22 % CONT:	ZONE 23A 49. 45.	ZONE 23 22. 4.
13	CZ 17 % CONT:	ZONE 9 62. 36.	CZ 17 8. 1.
			ZONE 3 20. 0.
			ZONE 18 22. 0.
			ZONE 7 36. 1.
			ZONE 5 15. 0.
			ZONE 0 0. 0.
			ZONE 11 COMP ZONE 6 0.
			ZONE 10 59. 39.
			ZONE 8 10. 2.
			ZONE 6 0. 0.
			ZONE 2 0. 0.
			ZONE 19 = ZONE 3. 0.
			ZONE 7 8. 6.
			CZ = ZONE ZONE 5 0. 0.
			ZONE 22 58. 42.
			ZONE 23 0. 0.
			ZONE 20 36. 1.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0



ROBINSON

Figure 2.11.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Robinson site.

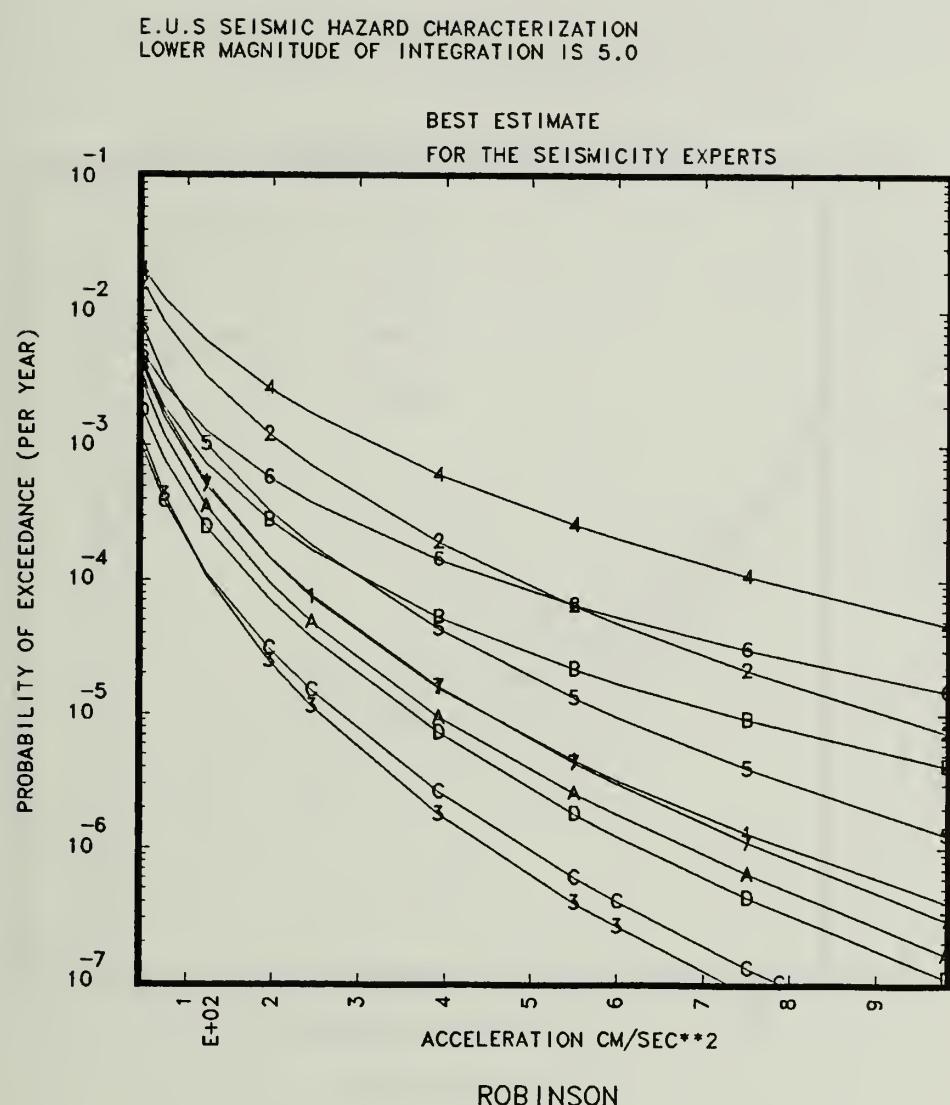
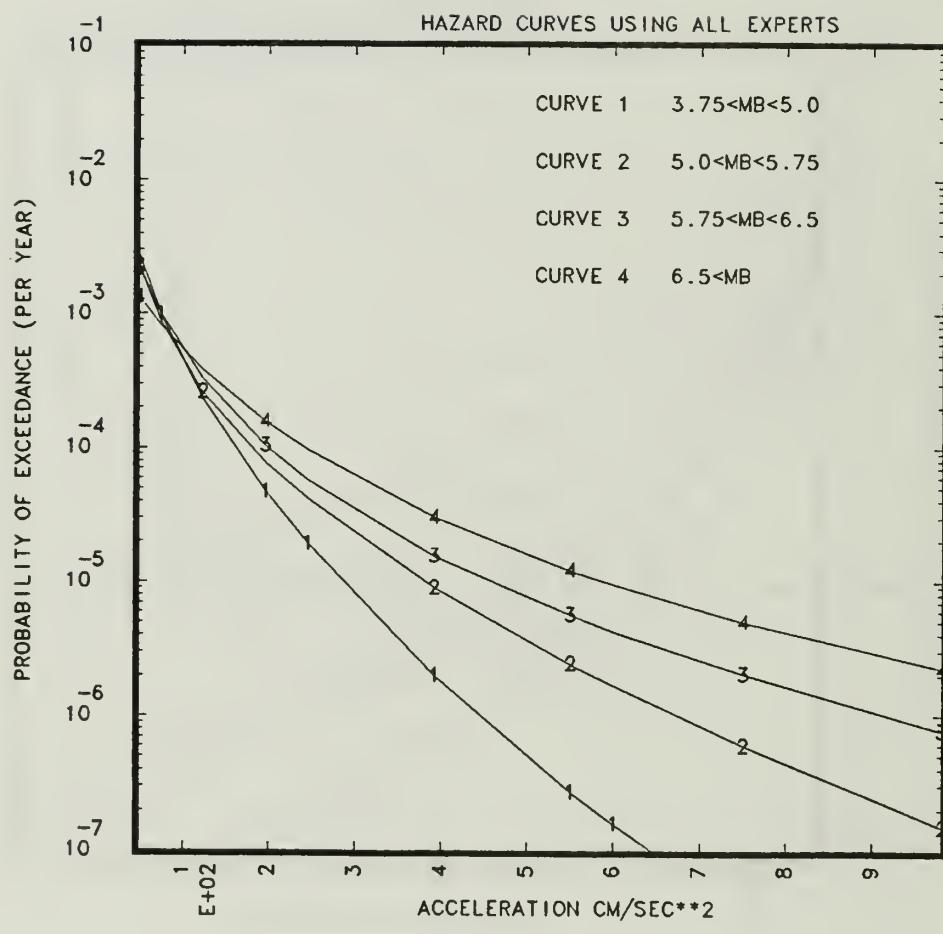


Figure 2.11.2 BEHCs per S-Expert combined over all G-Experts for the Robinson site. Plot symbols given in Table 2.0.



ROBINSON

Figure 2.11.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Robinson site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

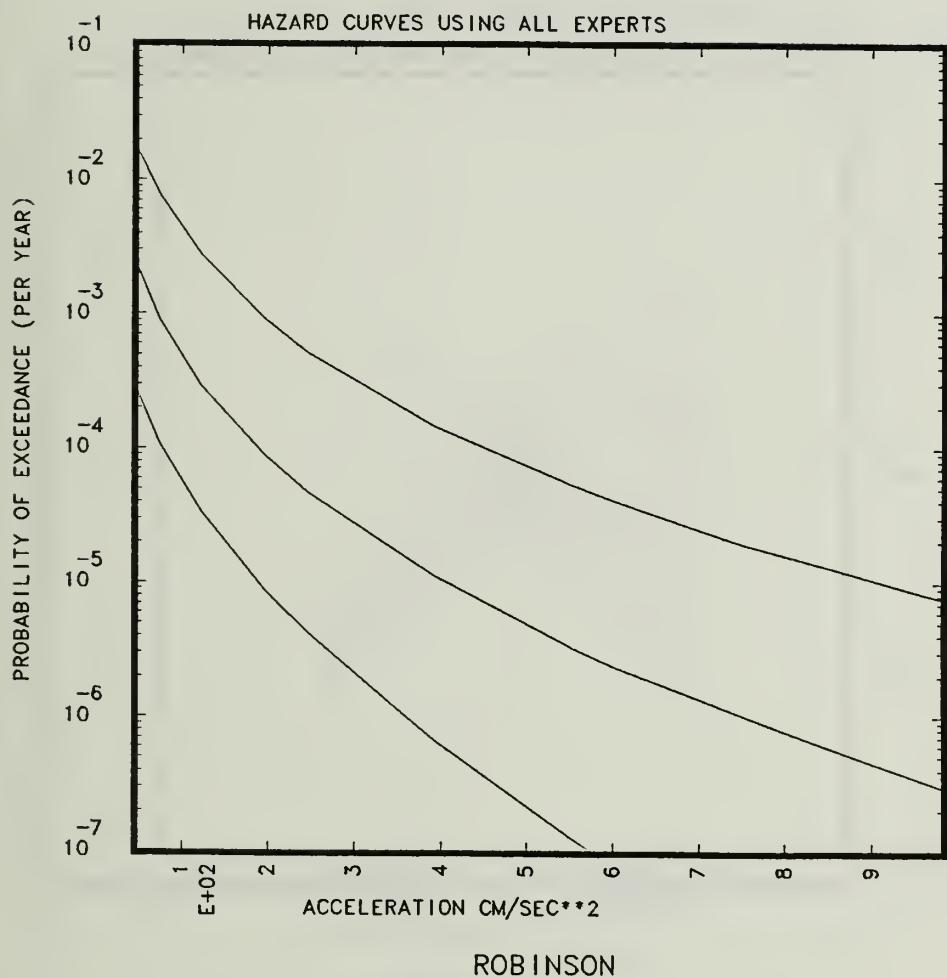


figure 2.11.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Robinson site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

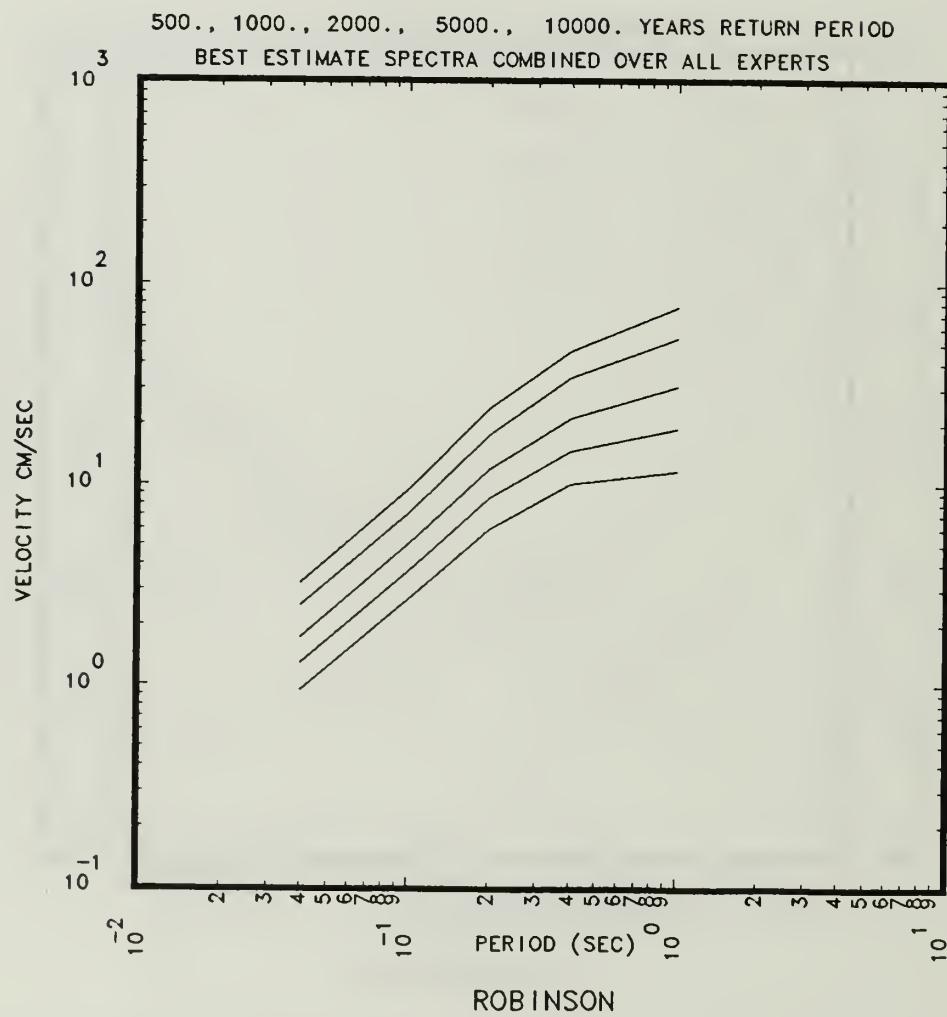


Figure 2.11.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Robinson site.

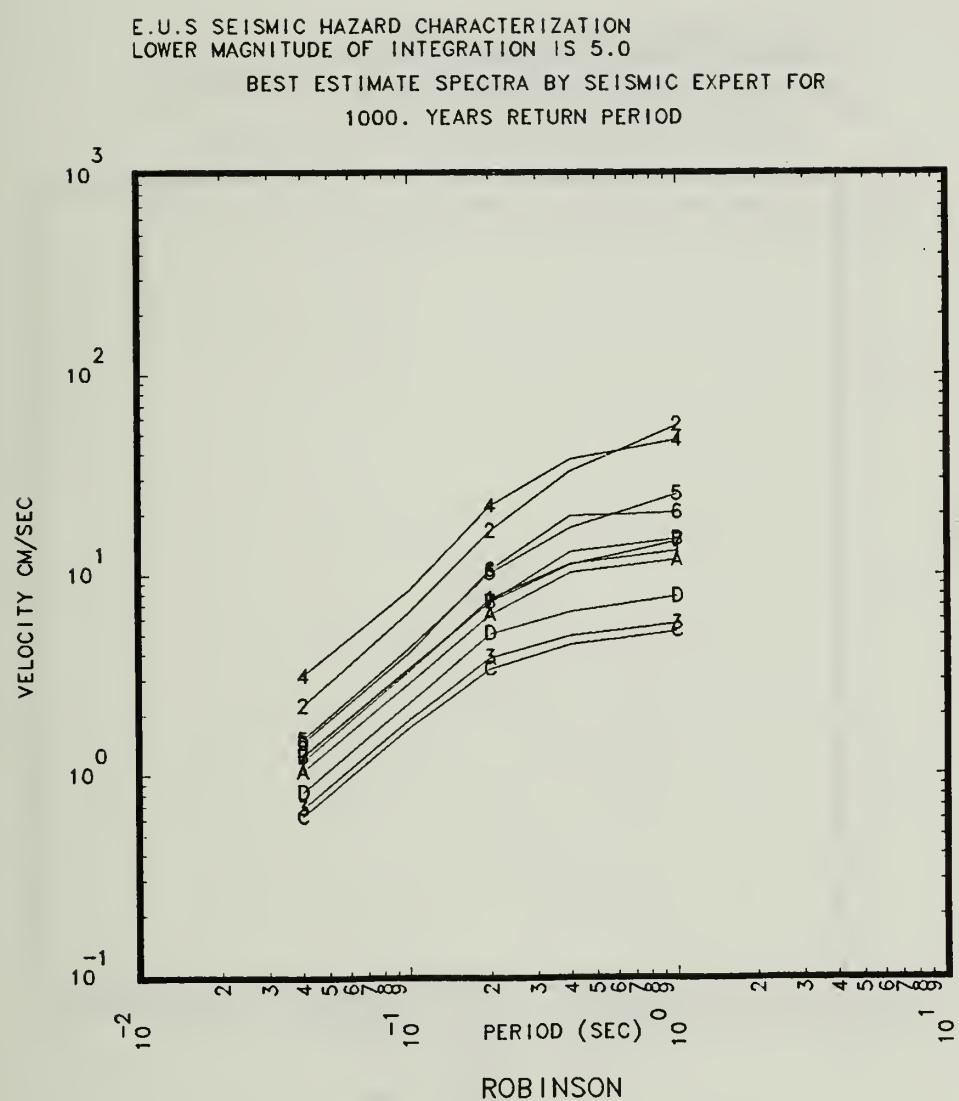


Figure 2.11.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Robinson site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

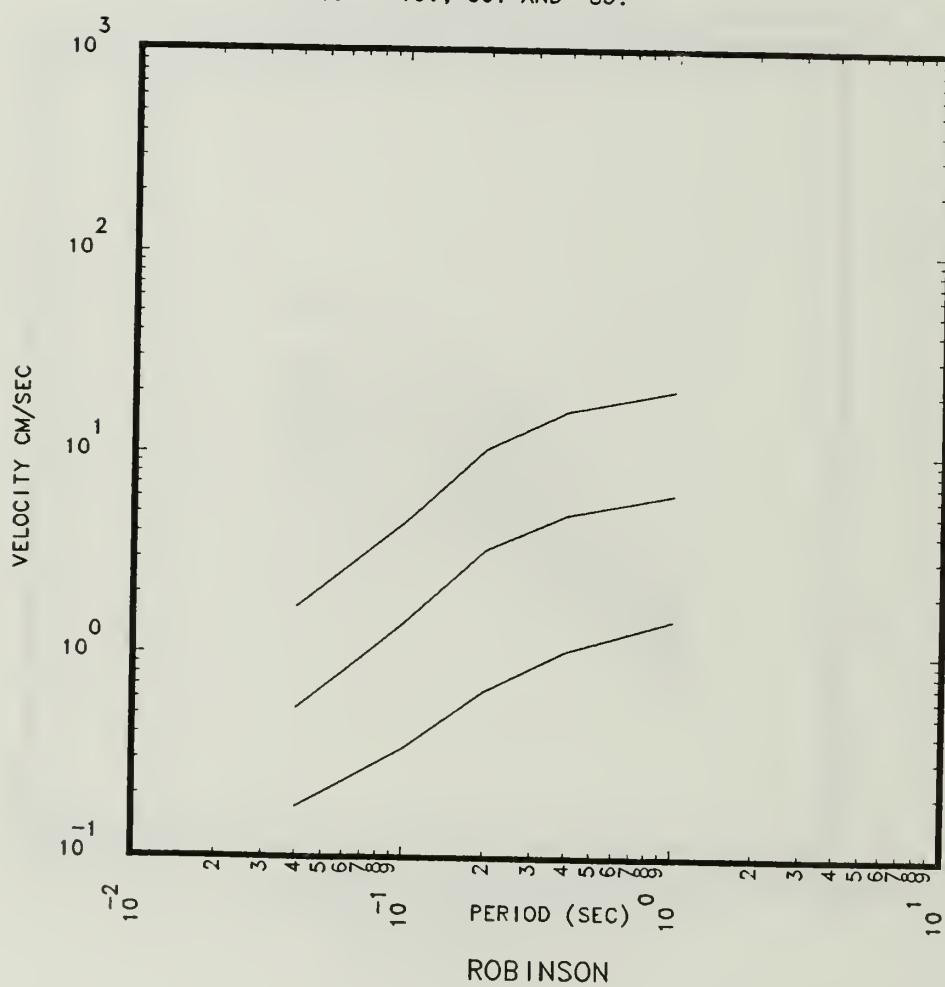


Figure 2.11.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Robinson site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

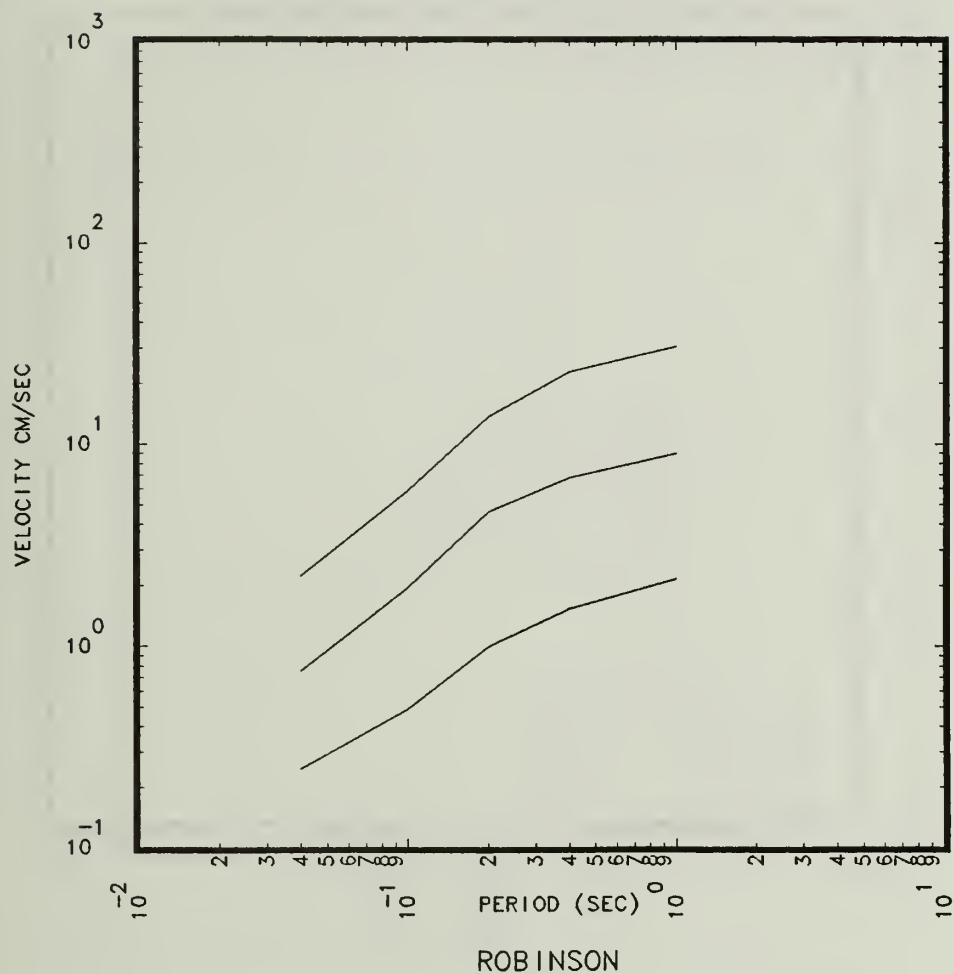


Figure 2.11.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Robinson site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

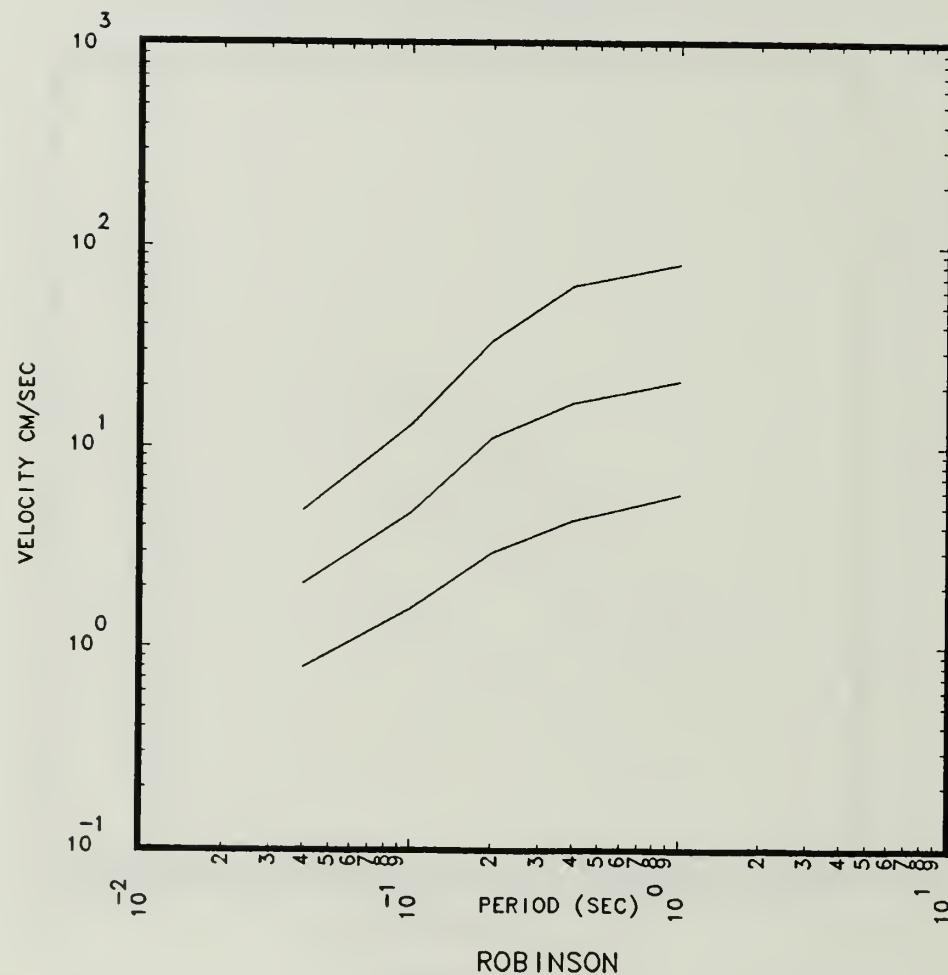


Figure 2.11.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Robinson site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

50-TH PERCENTILE SPECTRA FOR ALL RETURN PERIODS

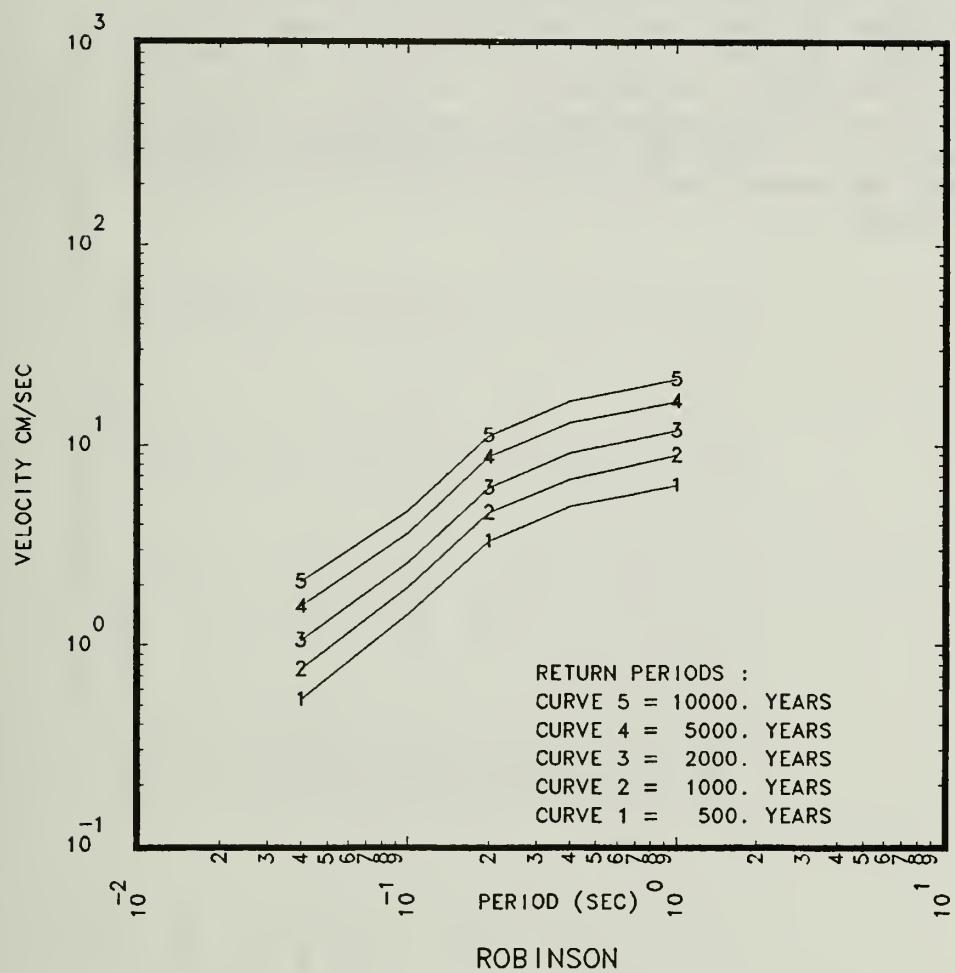


Figure 2.11.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Robinson site.

2.12 SEQUOYAH

The Sequoyah is a rock site represented by the symbol "C" on the location map in Fig. 1.1. Table 2.12.1 and Figs. 2.12.1 to 2.12.10 give the basic results for the Sequoyah site.

The AMHC is much higher than the 85th percentile CPHC, indicating the presence of outliers in the sample set of hazard curves generated in the Monte Carlo simulation (see Vol. I, Section 2.3).

The spread in the S-Experts' BEHC shown in Fig. 2.12.2. is relatively small, in part due to the fact that Sequoyah is centrally located, at some distance from the areas of high seismicity and capable of generating large earthquakes such as the New Madrid and the Charleston regions. Thus Fig. 2.12.2 reflects a relative degree of stability in the seismicity modeling for that region around the site. However, Table 2.12.1 shows that the New Madrid area contributes significantly to the hazard, as shown in Fig. 2.12.4 where large earthquakes (greater than magnitude 6.5) dominate the hazard for PGA values greater than 0.2g. Below 0.2g, the small earthquakes (less than magnitude 5.0) dominate the hazard and at 0.1g, one half of the hazard is contributed by small earthquakes.

TABLE 2.12.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR SEQUOYAH

SITE SOIL CATEGORY ROCK

S-XPT NUM.	HOST ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT HIGH PGA(0.60G)
1	ZONE 4	ZONE 4 % CONT.: 49. 32.	ZONE 9 9. ZONE 3 54.
2	ZONE 27	ZONE 18 % CONT.: 44. 35.	ZONE 27 ZONE 30 15. ZONE 20 ZONE 4 15.
3	ZONE 5	ZONE 5 % CONT.: 77. 11.	ZONE 13 ZONE 12 ZONE 9 7. ZONE 2.
4	ZONE 28	ZONE 4 % CONT.: 48. 34.	ZONE 28 ZONE 10 5. ZONE 8 ZONE 5.
5	ZONE 11	ZONE 11 % CONT.: 44. 38.	ZONE 15 ZONE 9 15. ZONE 14 ZONE 3.
6	ZONE 12	ZONE 12 % CONT.: 30. 22.	ZONE 13 ZONE 11 22. ZONE 17 16.
7	ZONE 7	ZONE 6 % CONT.: 57. 37.	ZONE 7 ZONE 10 3. ZONE 5.
10	ZONE 28	ZONE 12 % CONT.: 79. 12.	ZONE 12A ZONE 19 4. ZONE 10 ZONE 3.
11	ZONE 6	ZONE 6 % CONT.: 76. 7.	ZONE 8 6. ZONE 10 5.
12	ZONE 19	ZONE 19 % CONT.: 67.	ZONE 17 5. ZONE 15 19.
13	ZONE 8	ZONE 8 % CONT.: 73. 20.	ZONE 5 CZ 15 2. ZONE 9 ZONE 2.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

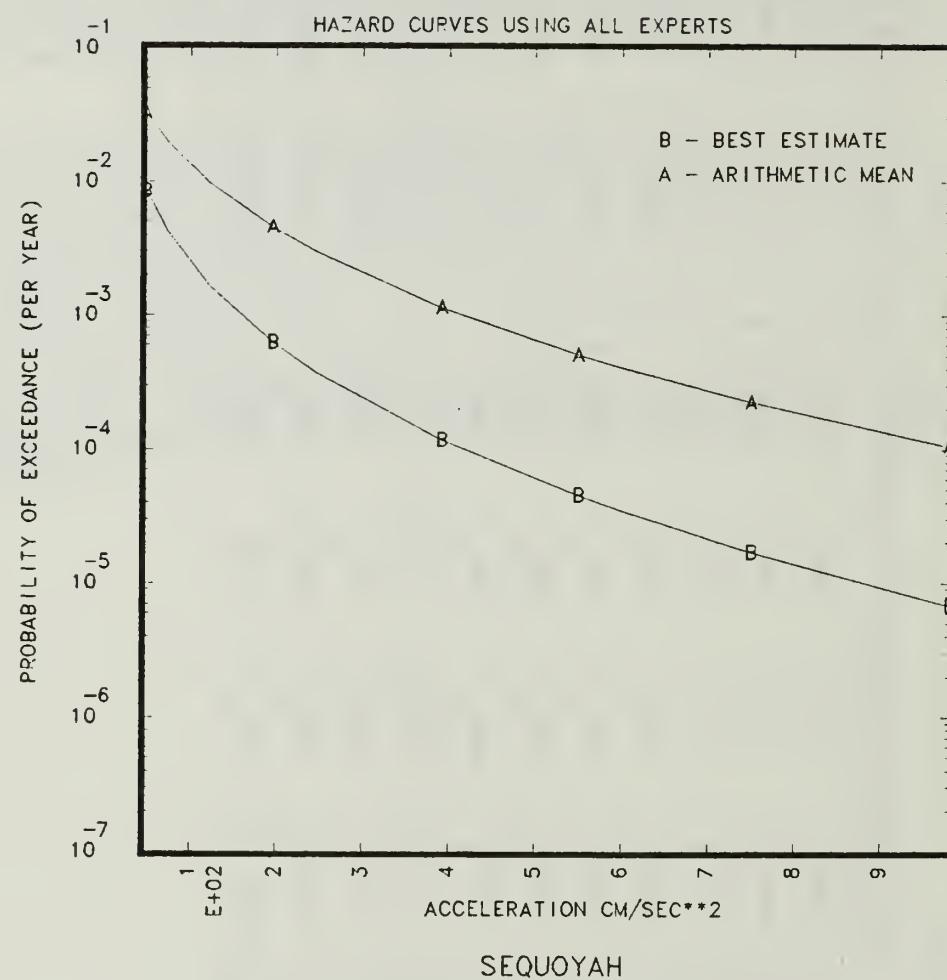


Figure 2.12.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Sequoyah site.

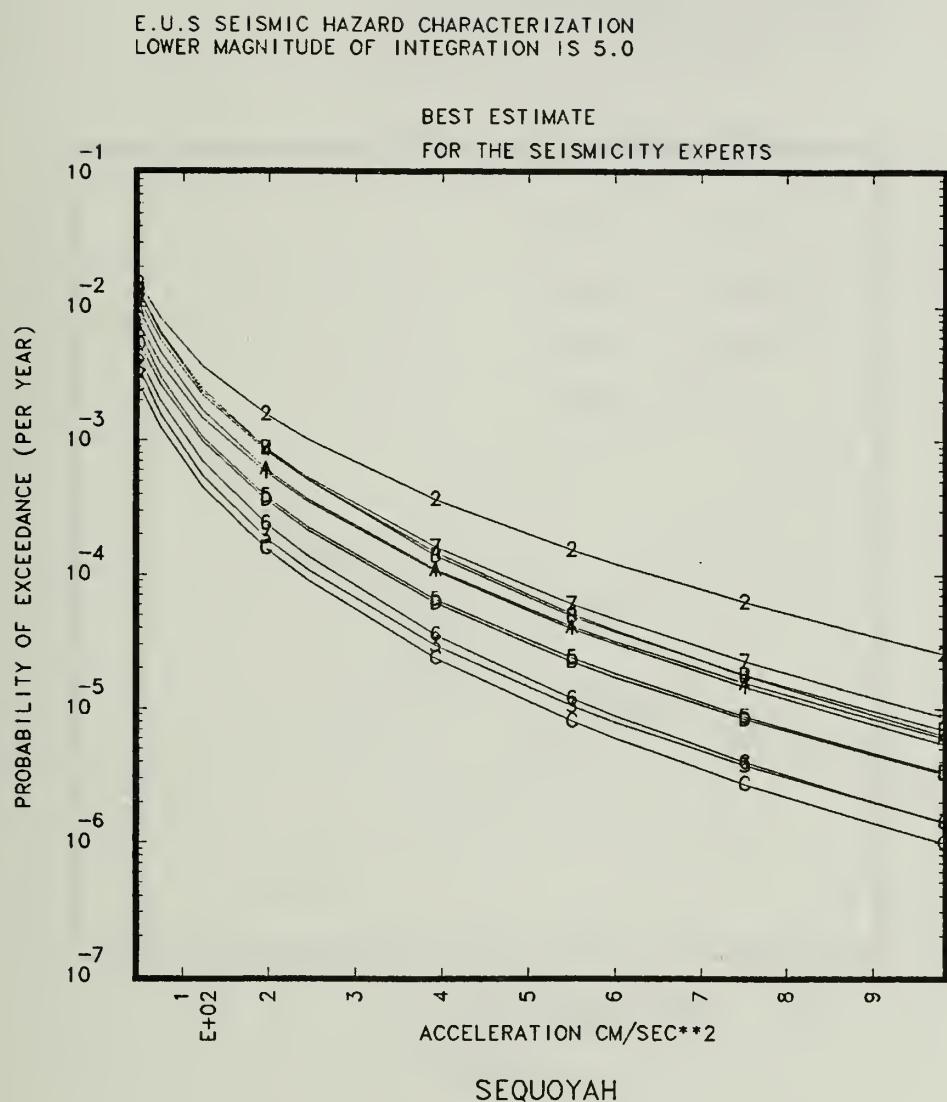


Figure 2.12.2 BEHCs per S-Expert combined over all G-Experts for the Sequoyah site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

PERCENTILES = 15., 50. AND 85.

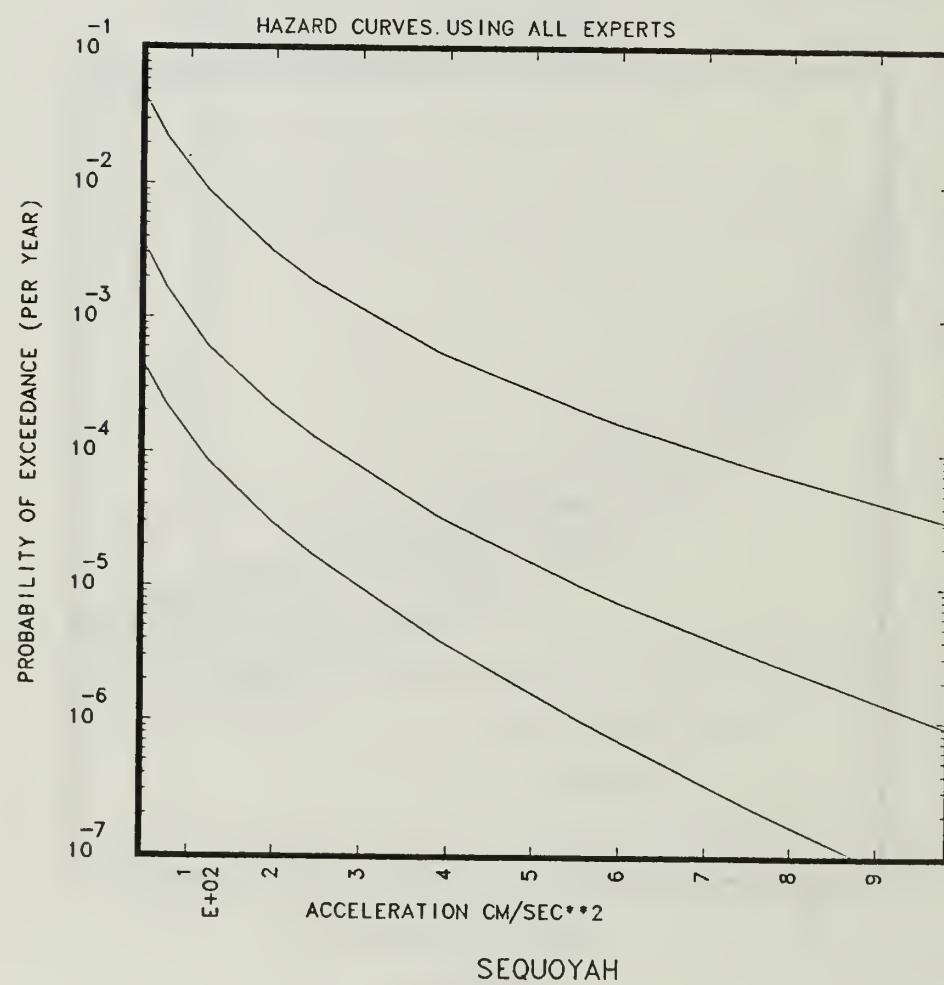


Figure 2.12.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Sequoyah site.

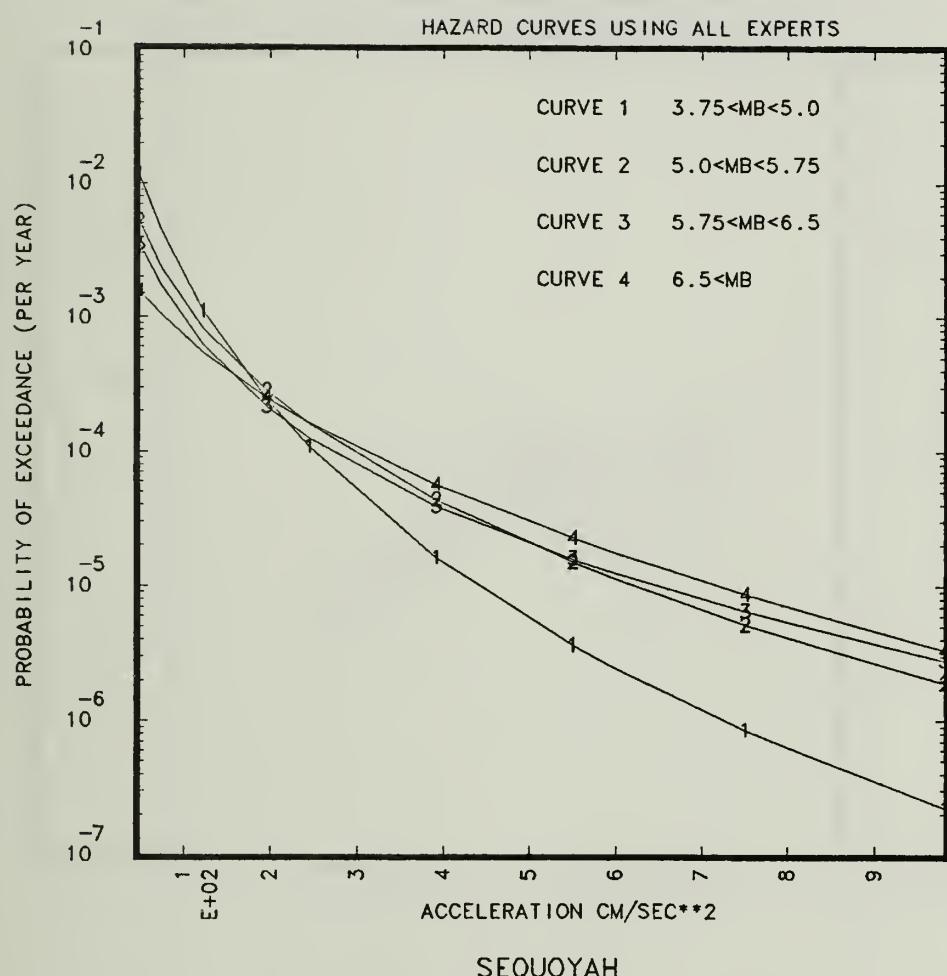


Figure 2.12.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Sequoyah site.

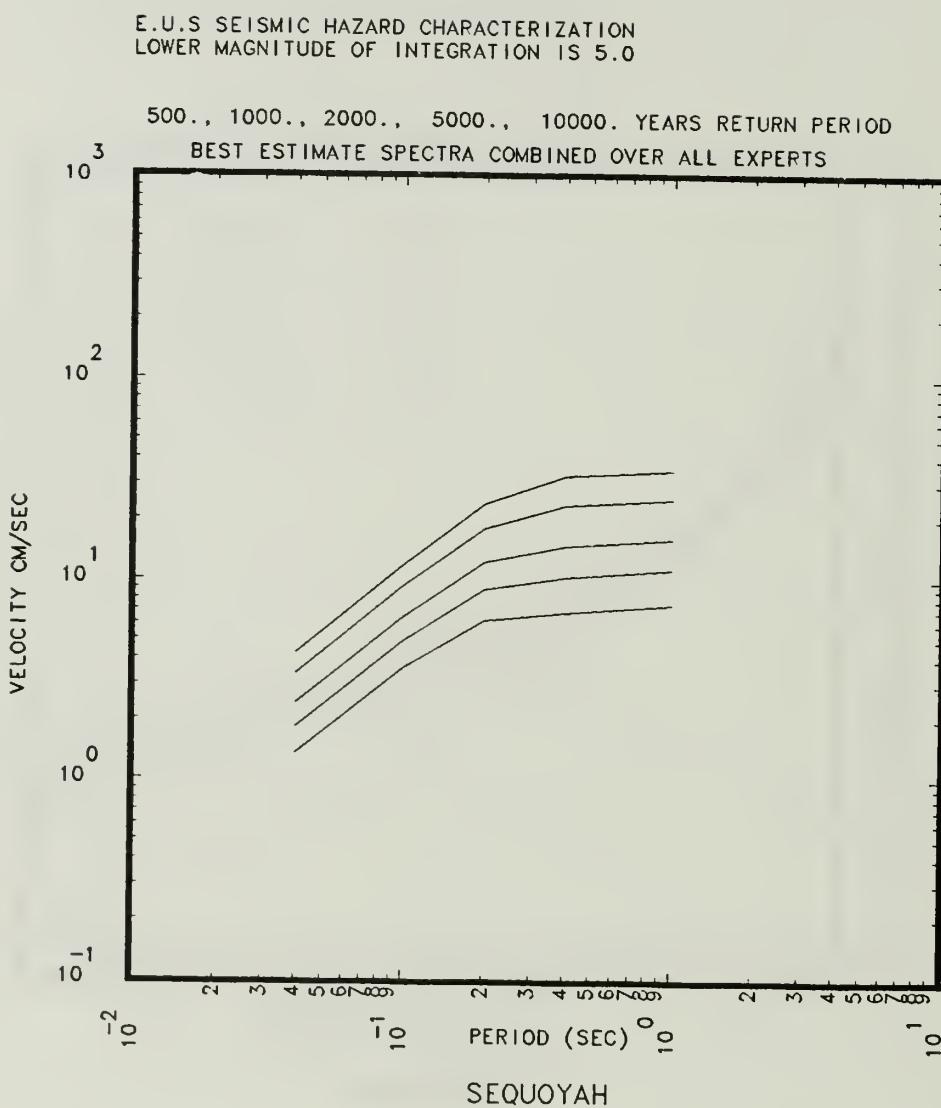


Figure 2.12.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Sequoyah site.

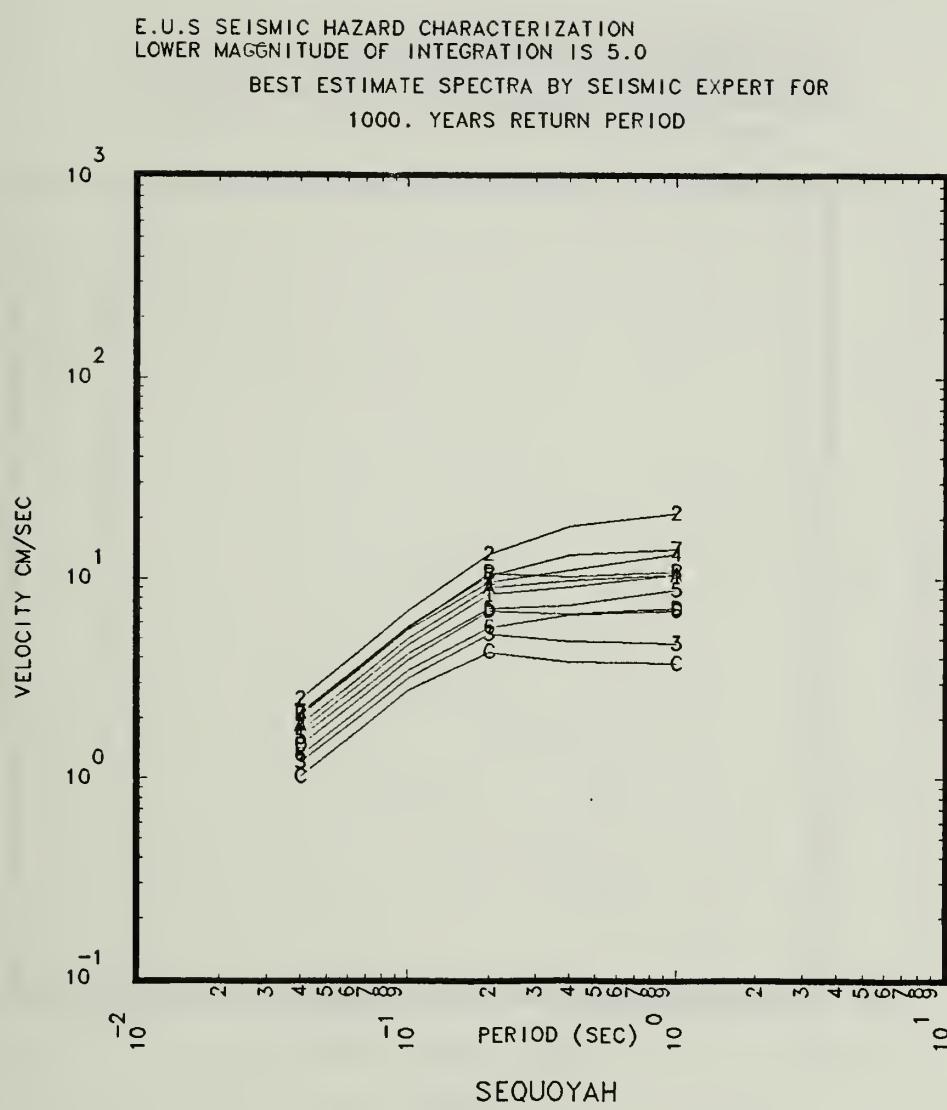


Figure 2.12.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Sequoyah site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

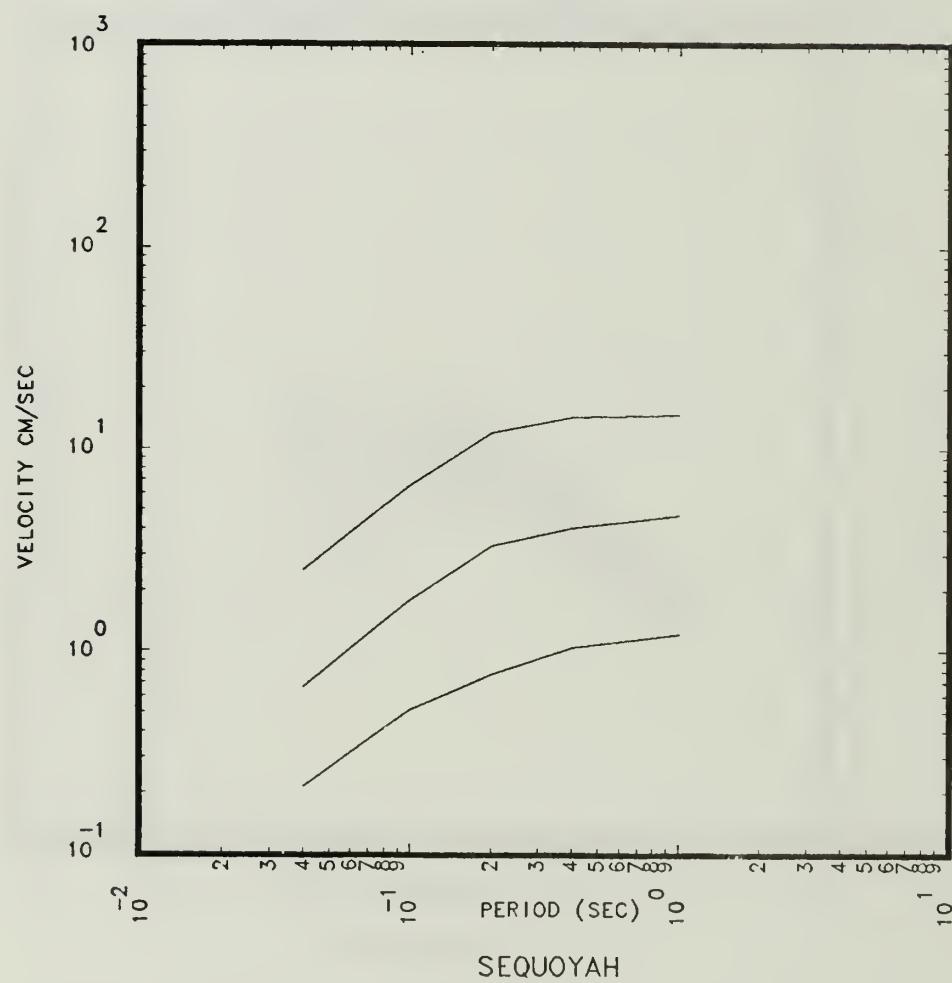


Figure 2.12.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Sequoyah site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

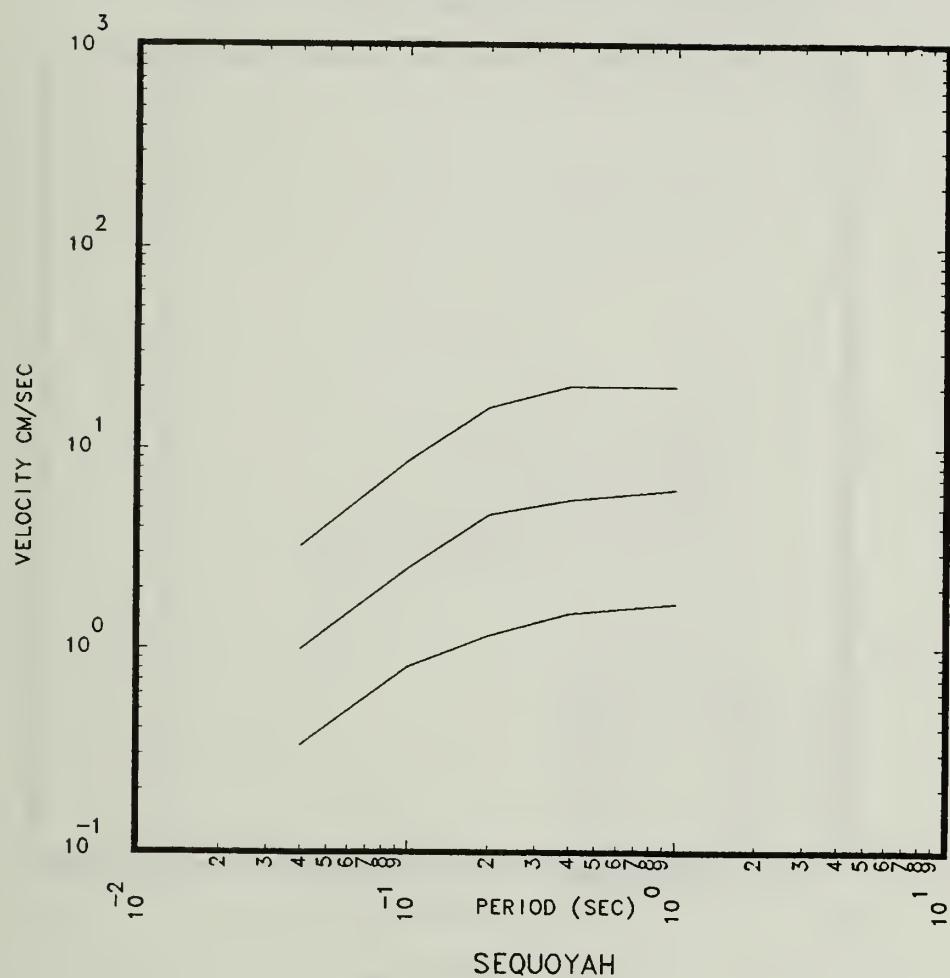


Figure 2.12.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Sequoyah site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

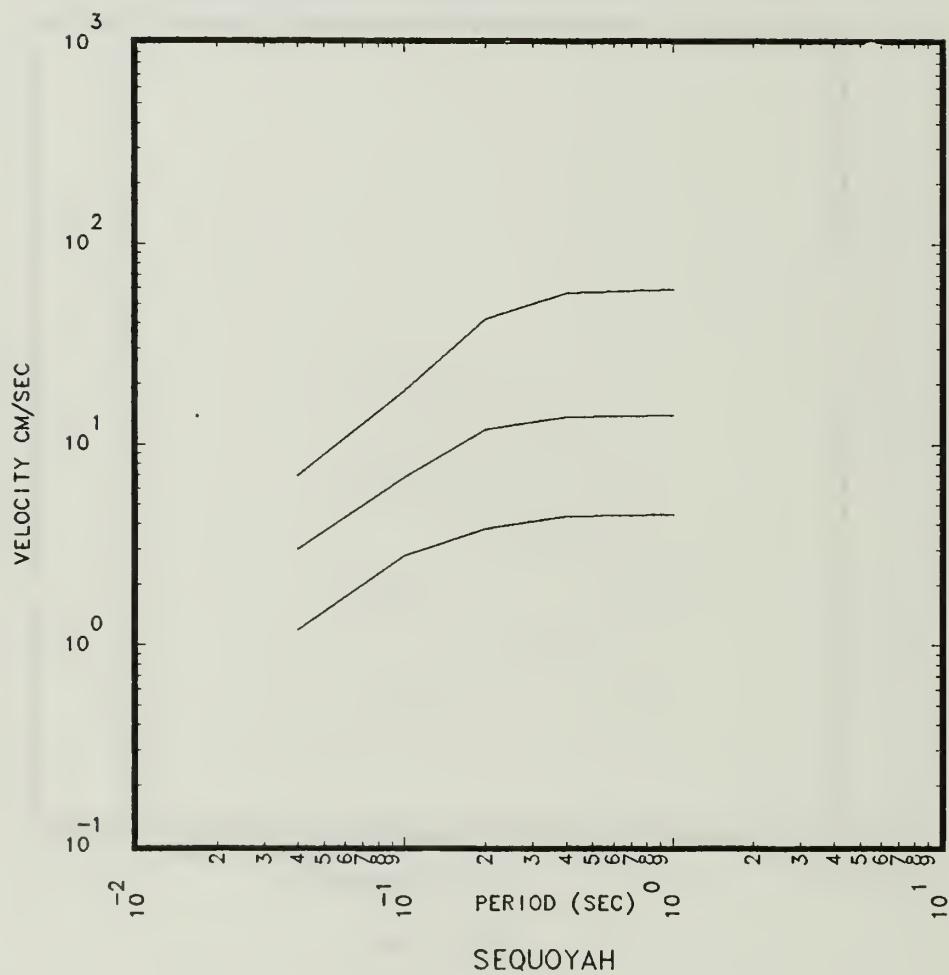


Figure 2.12.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Sequoyah site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

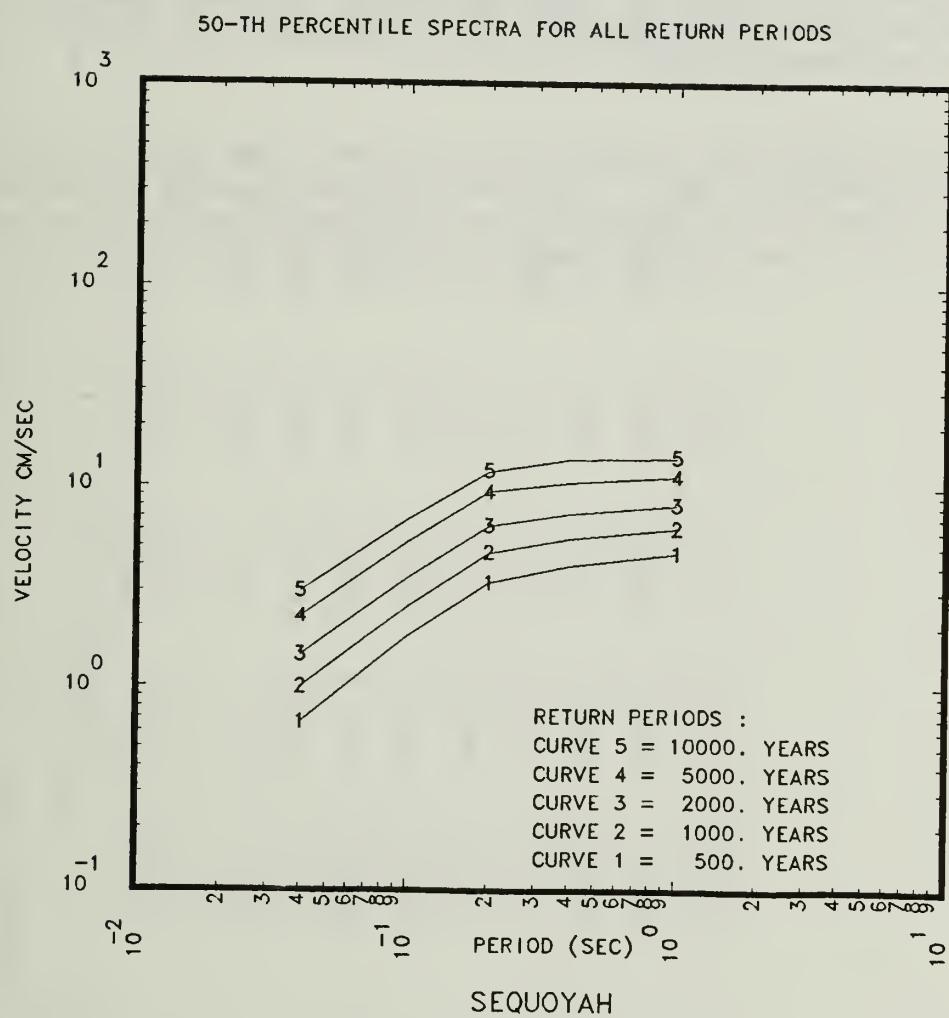


Figure 2.12.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Sequoyah site.

2.13 SHEARON HARRIS

Shearon Harris is a rock site represented by the symbol "D" on the location map in Fig. 1.1. Table 2.13.1 and Figs. 2.13.1 to 2.13.10 give the basic results for the Shearon Harris site.

The AMHC is much higher than the 85th percentile CPHC, indicating the presence of high outliers in the sample set of hazard curves generated in the Monte Carlo simulation (See Vol. I, Section 2.3). Table 2.13.1 shows that the Charleston area is the most significant contributor to the hazard for most S-Experts, thus it is not surprising to see in Fig. 2.13.4 that large earthquakes (greater than magnitude 6.5) dominate the hazard for PGA values greater than about 0.15g. At lower PGA values, the small earthquakes (lower than magnitude 5.0) dominate such that including them in the analysis would multiply the hazard by 1.5.

Figure 2.13.6 shows the 5% damping best estimate 1000 year response spectra for each of the 11 S-Experts. The shape of these spectra is similar to those observed in Section 2.1, especially for S-Experts 1 and 11. Also see Section 2.1 for other typical comments for rock sites.

TABLE 2.13.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR SHEARON HARRIS

SITE SOIL CATEGORY ROCK

S-EXP. ZONE NUM.	HOLD ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G) AT HIGH PGA(0.60G)
1 ZONE 3	ZONE ID: ZONE 3 % CONT.: 63.	ZONE 2 ZONE 22. ZONE 1 ZONE 4 ZONE 4.
2 COMP. ZG	ZONE ID: ZONE 30 % CONT.: 78.	ZONE 27 ZONE 8. COMP. ZON 5. COMP. ZON 4.
3 ZONE 7	ZONE ID: ZONE 7 % CONT.: 62.	ZONE 9 ZONE 17. ZONE 5 ZONE 8A ZONE 7.
4 ZONE 11	ZONE ID: ZONE 10 % CONT.: 68.	ZONE 11 ZONE 15. ZONE 9 ZONE 6. ZONE 26
5 ZONE 10	ZONE ID: ZONE 9 % CONT.: 73.	ZONE 10 ZONE 22. ZONE 8 ZONE 2. ZONE 11
6 COMP. ZG	ZONE ID: ZONE 13 % CONT.: 57.	ZONE 11 ZONE 21. ZONE 15 COMP. ZON 16. COMP. ZON 4.
7 ZONE 2 =	ZONE ID: ZONE 10 % CONT.: 62.	ZONE 7 ZONE 14. ZONE 8 ZONE 9 ZONE 8.
10 ZONE 4B	ZONE ID: ZONE 4B % CONT.: 55.	ZONE 28 ZONE 15 ZONE 15. ZONE 11. ZONE 28A ZONE 17. ZONE 15.
11 ZONE 7	ZONE ID: ZONE 7 % CONT.: 48.	ZONE 8 ZONE 43. ZONE 6 ZONE 5 ZONE 2.
12 ZONE 22	ZONE ID: ZONE 22 % CONT.: 52.	ZONE 23A ZONE 24. ZONE 20 ZONE 17. ZONE 32 ZONE 3.
13 CZ 17	ZONE ID: CZ 17 % CONT.: 59.	ZONE 9 ZONE 28. ZONE 8 CZ 15 ZONE 12. CZ 175. 1.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

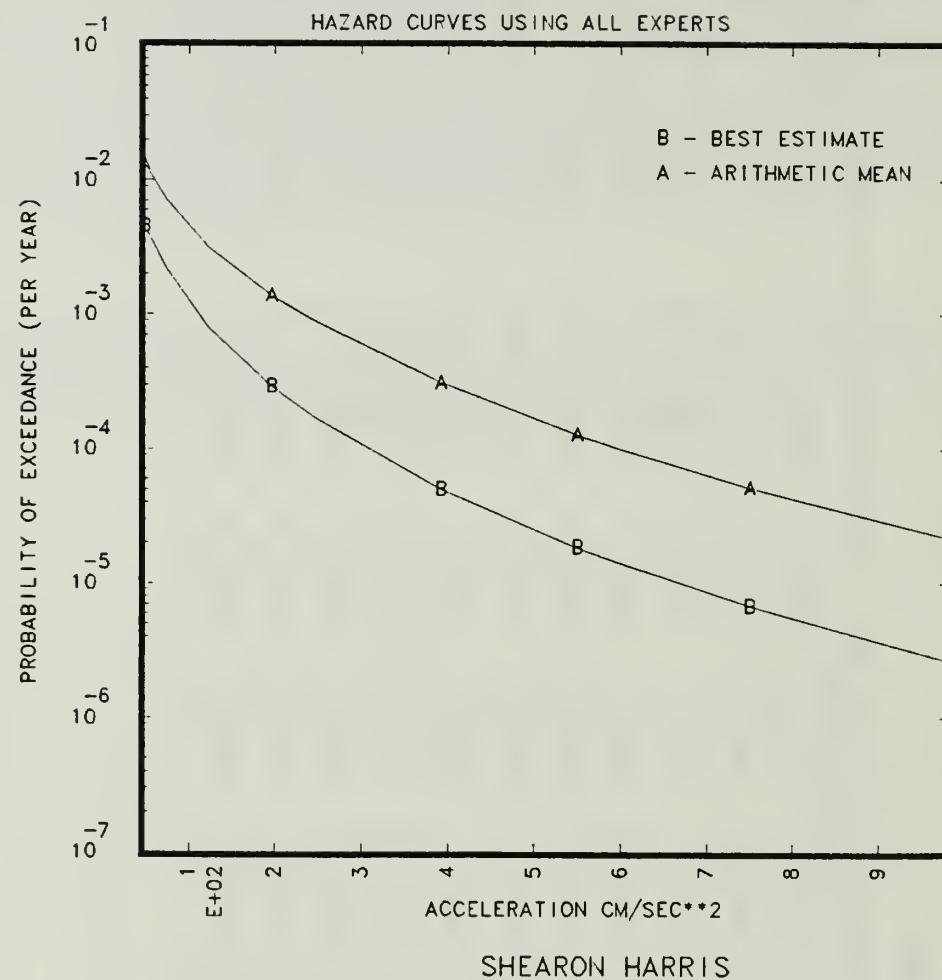


Figure 2.13.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Shearon Harris site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

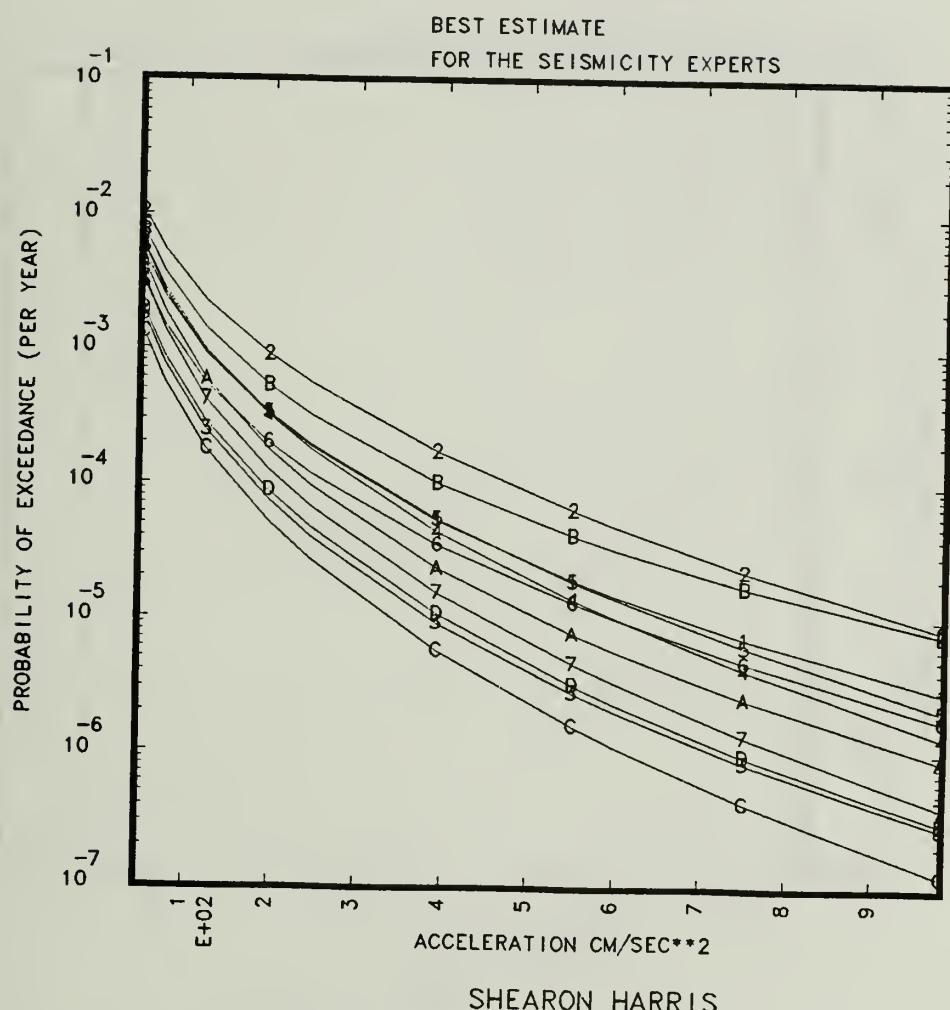


Figure 2.13.2 BEHCs per S-Expert combined over all G-Experts for the Shearon Harris site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

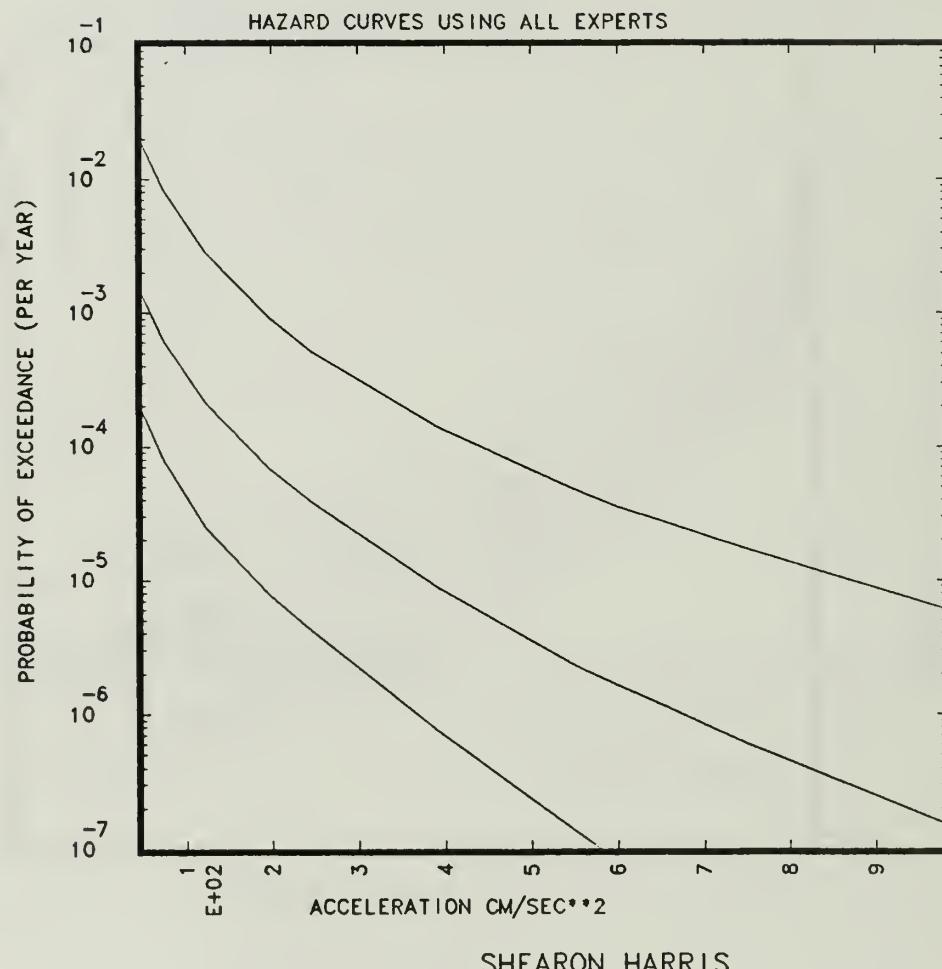


Figure 2.13.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Shearon Harris site.

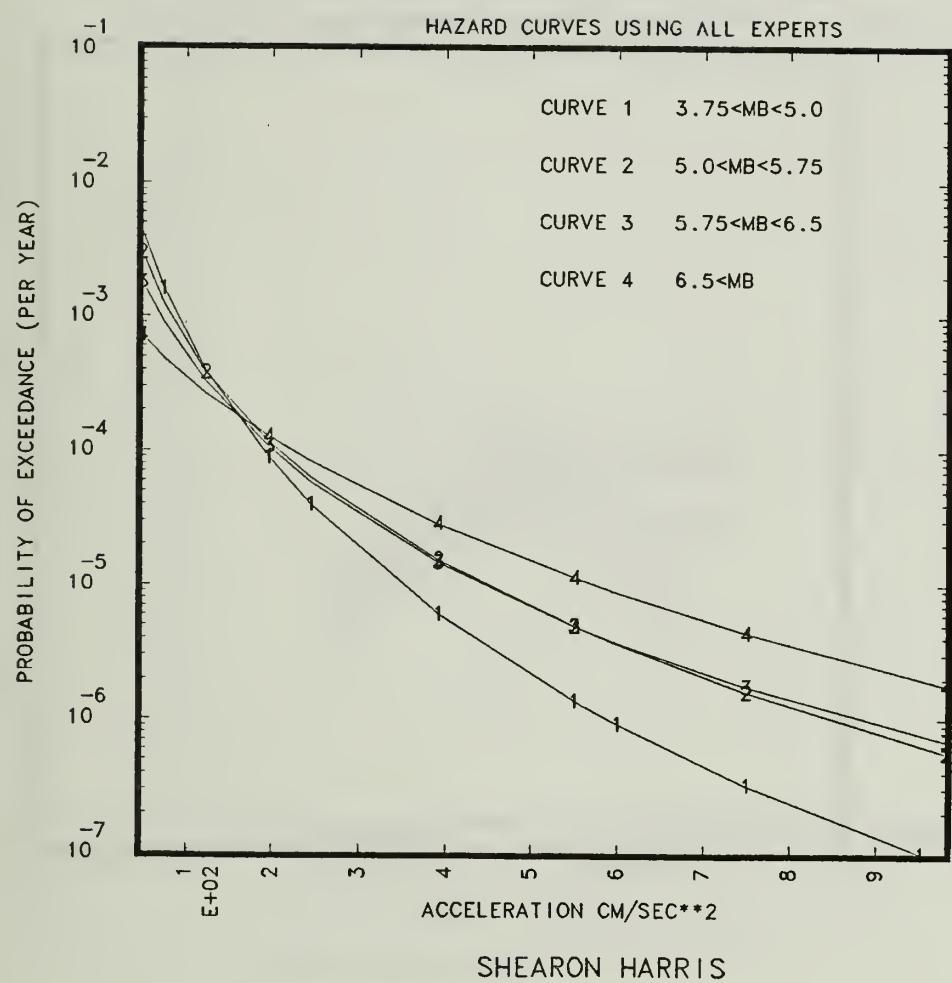


Figure 2.13.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Shearon Harris site.

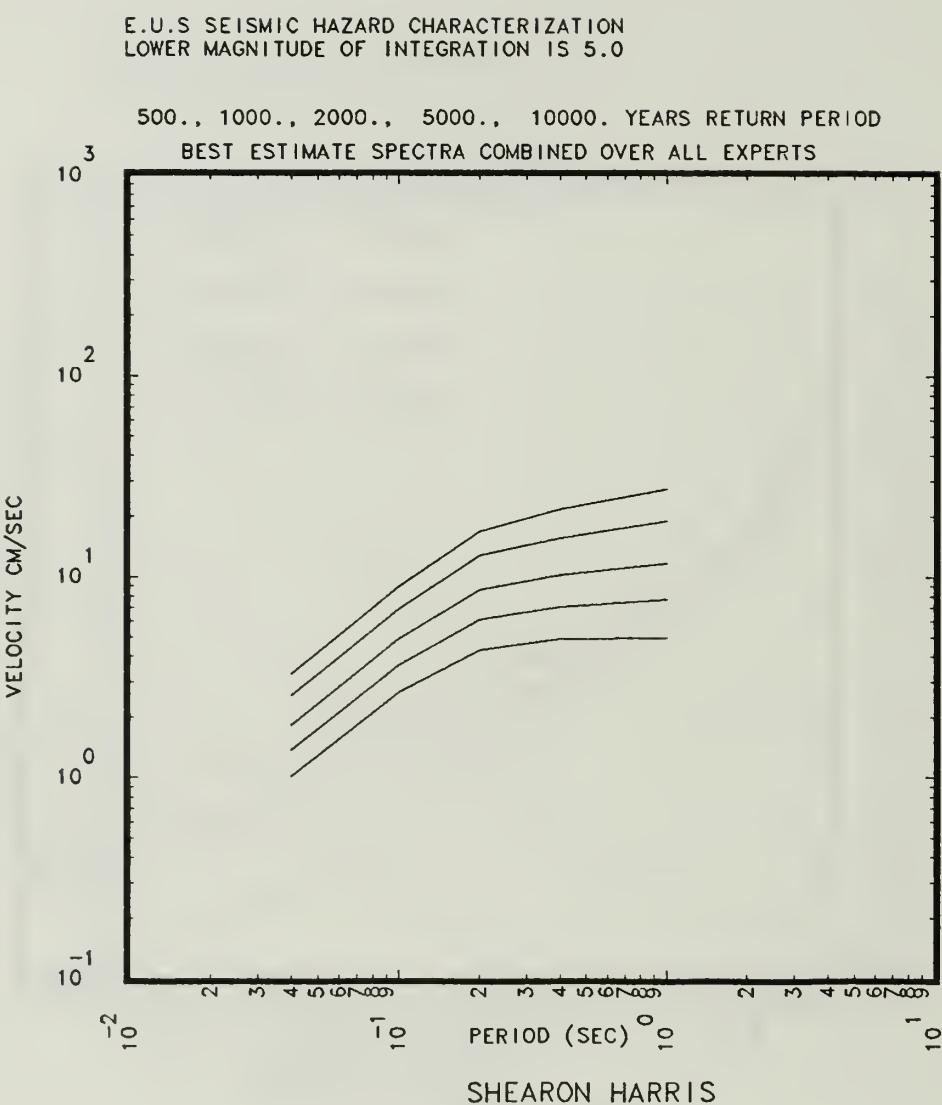


Figure 2.13.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Shearon Harris site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

BEST ESTIMATE SPECTRA BY SEISMIC EXPERT FOR
1000. YEARS RETURN PERIOD

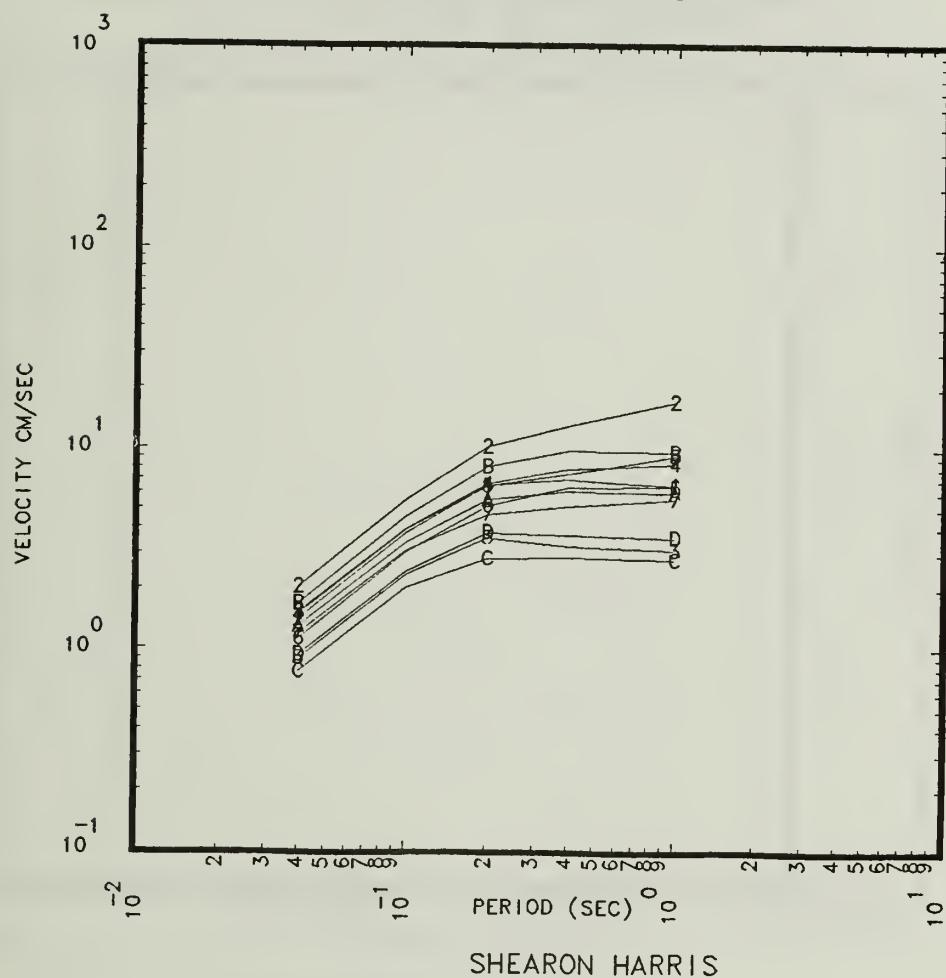


Figure 2.13.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Shearon Harris site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

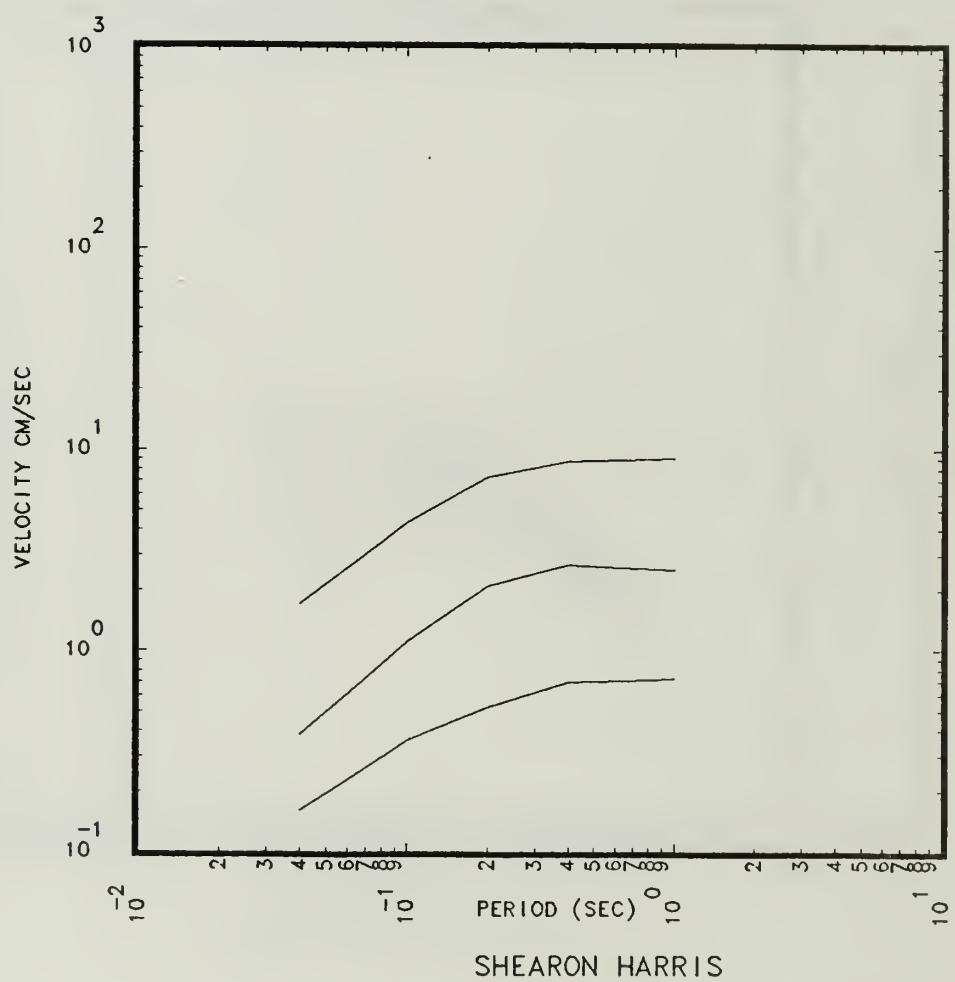


Figure 2.13.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Shearon Harris site.

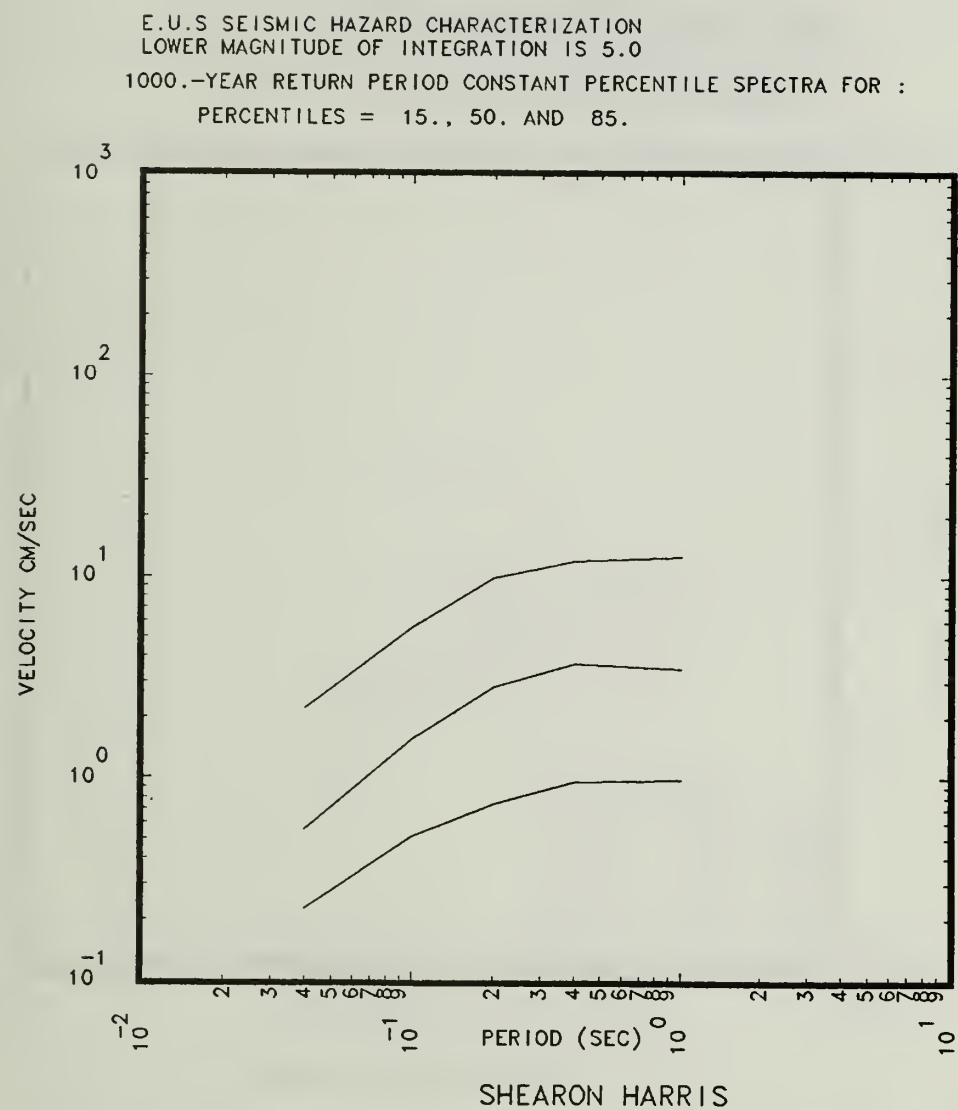
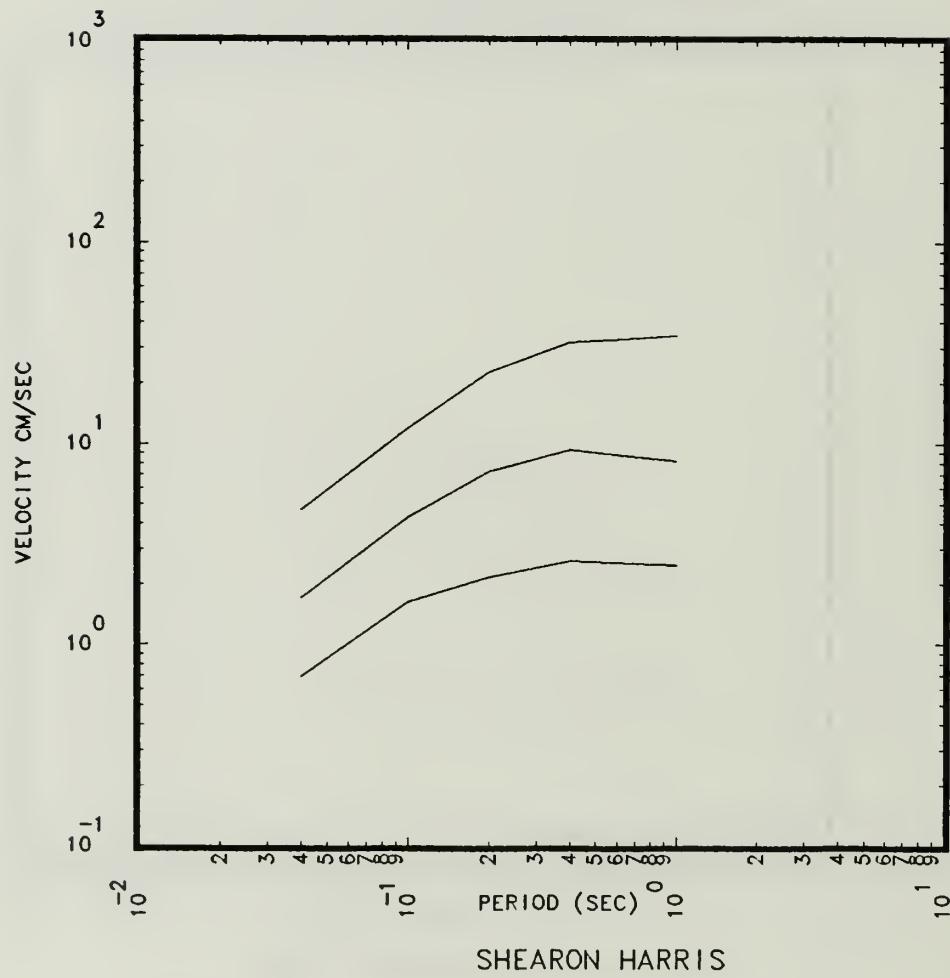


Figure 2.13.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Shearon Harris site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.



SHEARON HARRIS

Figure 2.13.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Shearon Harris site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

50-TH PERCENTILE SPECTRA FOR ALL RETURN PERIODS

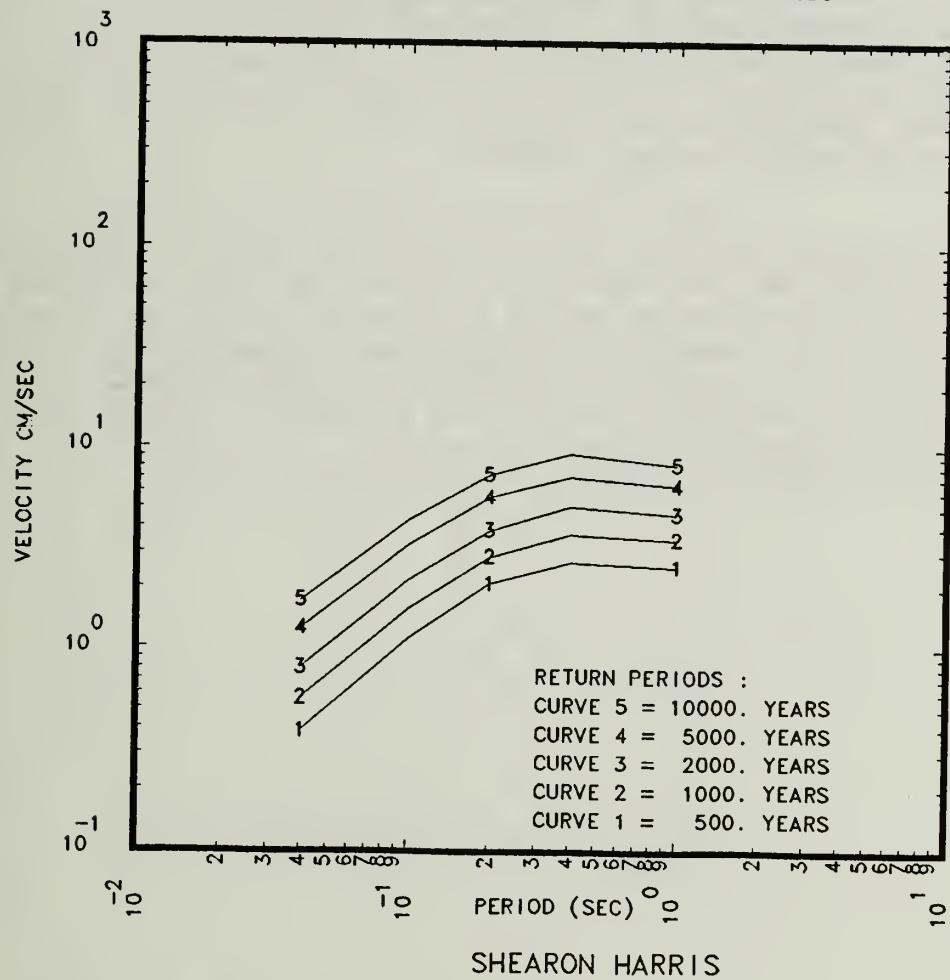


Figure 2.13.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Shearon Harris site.

2.14 SUMMER

Summer is a rock site represented by the symbol "E" on the location map in Fig. 1.1. Table 2.14.1 and Figs. 2.14.1 to 2.14.10 give the basic results for the Summer site.

The AMHC is much higher, (up to a factor of four times at 0.5g) than the 85th percentile CPHC, indicating relatively high numbers of outliers in the sample set of hazard curves generated in the Monte Carlo simulation (See Vol. I, Section 2.3).

The spread of the BEHC for all S-Experts shown in Fig. 2.14.2 is typical for the region 2 (southeastern U.S.). Because of the site's location (between both the New Madrid and the Charleston areas), the dominant areas of contribution to the hazard are at large distance from the site (more than 150 km). Indeed, Table 2.14.1 shows that the distant Charleston area contributes the most to the hazard for most S-Experts.

Figure 2.14.4 shows that above 0.15g the small earthquakes (smaller than magnitudes 5.0) do not contribute to the hazard, at 0.1g. Including the small earthquakes would increase the hazard by about 30 percent and 60 percent at 0.05g. Figure 2.14.6 shows the 5% damping best estimate 1000 year response spectra for each of the S-Experts. The shape of these spectra is similar to those observed at the Bellefonte rock site discussed in Section 2.1, especially for S-Expert 11 (symbol "B" on Figs. 2.14.6 and 2.1.6). See Section 2.1 for additional comments on typical rock sites.

TABLE 2.14.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR SUMMER

SITE SOIL CATEGORY ROCK

S-EXP. HOST NUM.	HOST ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)								
1	ZONE 3	ZONE ID: ZONE 3 % CONT: 41.	ZONE 2 39.	ZONE 9 10.	ZONE 1 5.	ZONE 5 57.	ZONE 3 35.	ZONE 2 35.	ZONE 9 5.	ZONE 1 3.
2	ZONE 29	ZONE ID: ZONE 30 % CONT: 64.	ZONE 29 22.	ZONE 9 9.	ZONE 8 3.	ZONE 27 80.	ZONE 30 80.	ZONE 29 16.	ZONE 18 3.	ZONE 27 0.
3	ZONE 7	ZONE ID: ZONE 9 % CONT: 47.	ZONE 7 41.	ZONE 5 6.	ZONE 8 2.	ZONE 7 55.	ZONE 9 44.	ZONE 9 44.	ZONE 8 1.	ZONE 5 0.
4	ZONE 9	ZONE ID: ZONE 10 % CONT: 67.	ZONE 9 24.	ZONE 6 6.	ZONE 4 1.	ZONE 28 71.	ZONE 10 28.	ZONE 9 28.	ZONE 4 1.	ZONE 28 0.
5	ZONE 10	ZONE ID: ZONE 9 % CONT: 80.	ZONE 10 14.	ZONE 15 4.	ZONE 11 2.	ZONE 9 91.	ZONE 10 91.	ZONE 10 7.	ZONE 15 1.	ZONE 11 0.
6	ZONE 13	ZONE ID: ZONE 13 % CONT: 94.	ZONE 11 4.	ZONE 17 1.	ZONE 18 0.	ZONE 18 0.	ZONE 13 99.	ZONE 11 99.	ZONE 14 0.	ZONE 18 0.
7	ZONE 8	ZONE ID: ZONE 10 % CONT: 48.	ZONE 8 25.	ZONE 6 21.	ZONE 7 5.	ZONE 6 66.	ZONE 10 66.	ZONE 8 24.	ZONE 15 1.	ZONE 11 1.
10	ZONE 4B	ZONE ID: ZONE 28 % CONT: 49.	ZONE 15 24.	ZONE 4B 22.	ZONE 28A 2.	ZONE 4B 40.	ZONE 4B 39.	ZONE 28 39.	ZONE 15 20.	ZONE 19 0.
11	ZONE 7	ZONE ID: ZONE 7 % CONT: 54.	ZONE 8 38.	ZONE 6 4.	ZONE 6 2.	ZONE 11 65.	ZONE 8 65.	ZONE 7 35.	CZ = ZONE 7 0.	ZONE 6 0.
12	ZONE 22	ZONE ID: ZONE 23A % CONT: 47.	ZONE 22 30.	ZONE 20 8.	ZONE 23 6.	ZONE 23A 70.	ZONE 22 70.	ZONE 20 26.	ZONE 23 2.	ZONE 19 1.
13	CZ 17	ZONE ID: ZONE 9 % CONT: 52.	CZ 17 32.	ZONE 8 9.	ZONE 5 5.	ZONE 9 71.	CZ 17 71.	ZONE 8 27.	ZONE 1 1.	ZONE 5 1.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

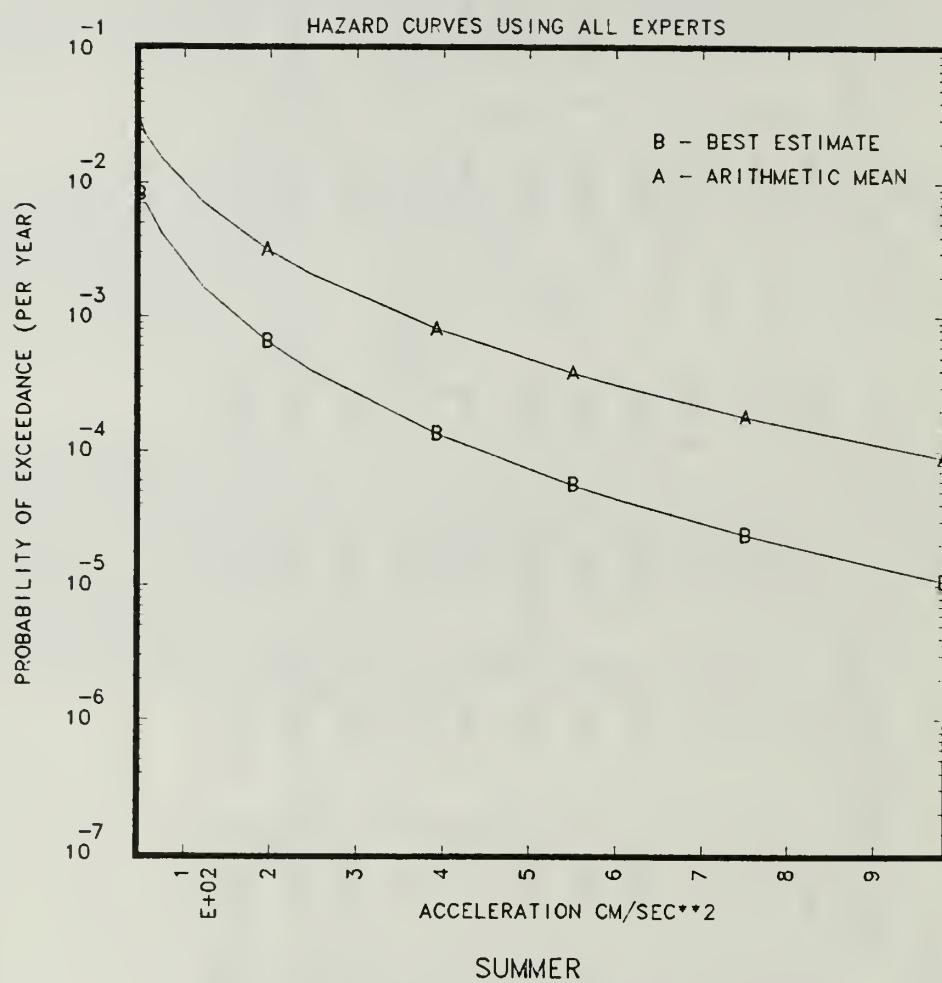


Figure 2.14.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Summer site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

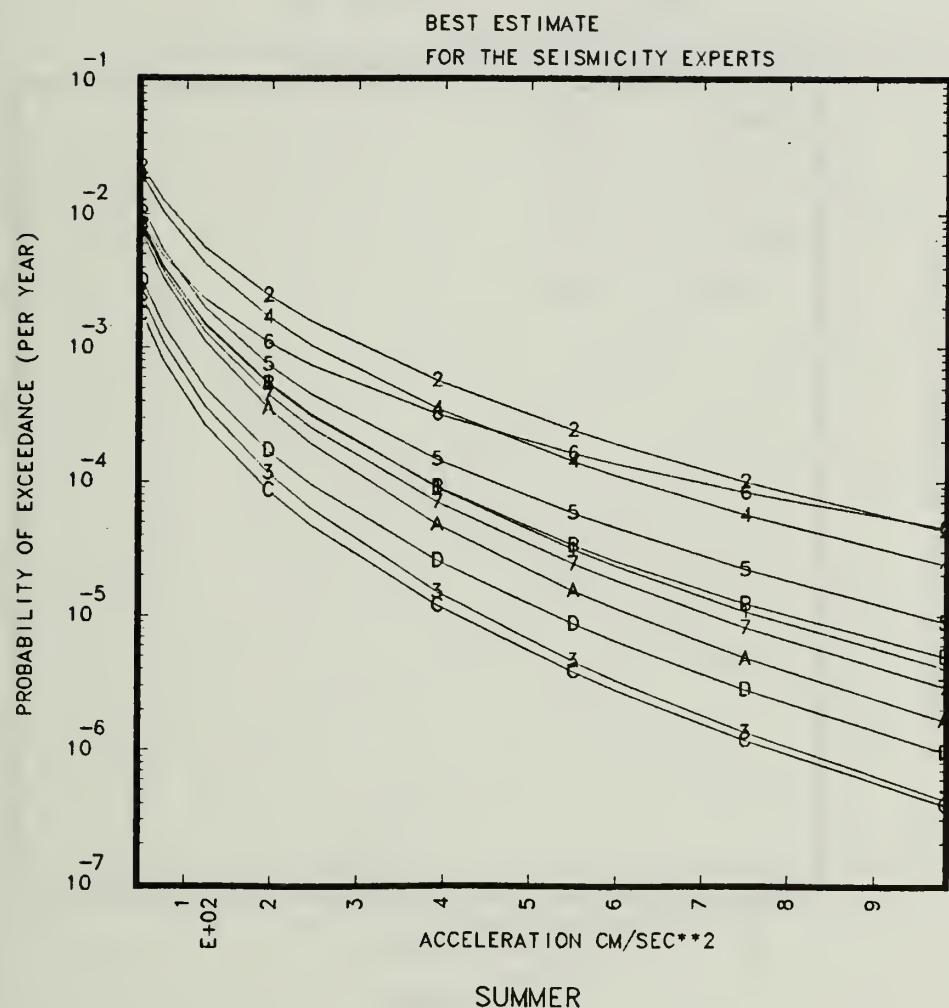


Figure 2.14.2 BEHCs per S-Expert combined over all G-Experts for the Summer site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

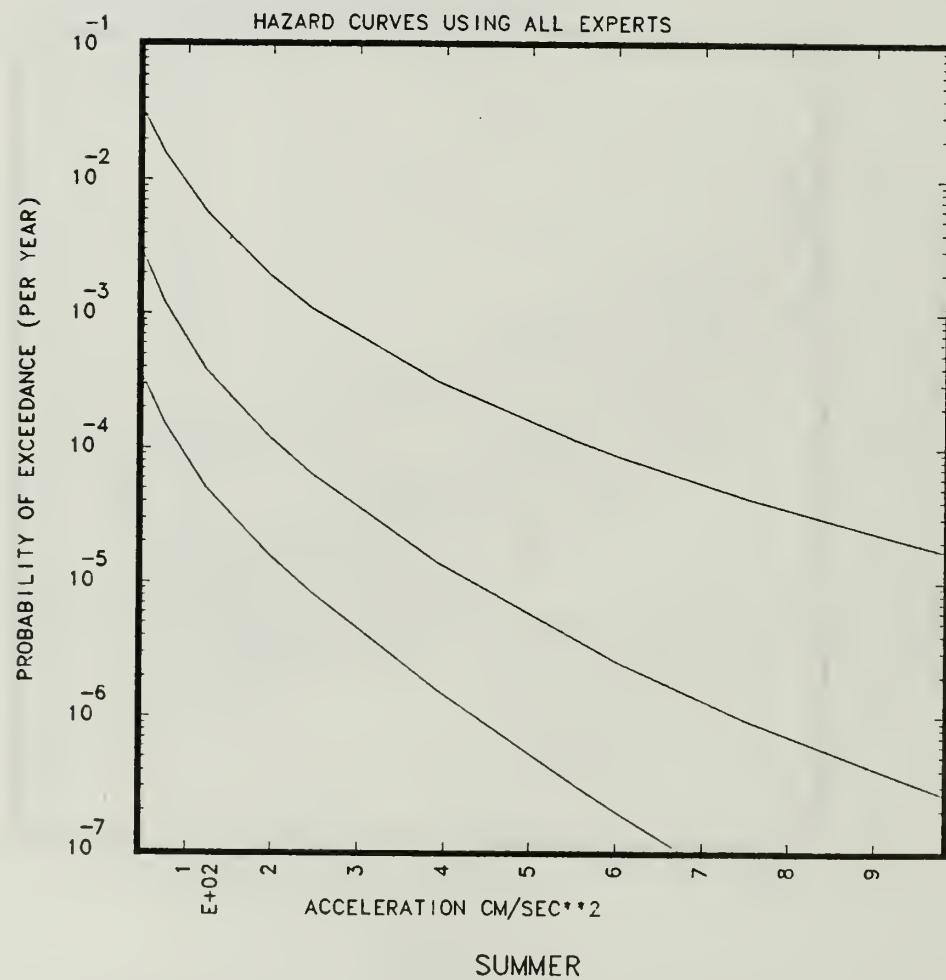


Figure 2.14.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Summer site.

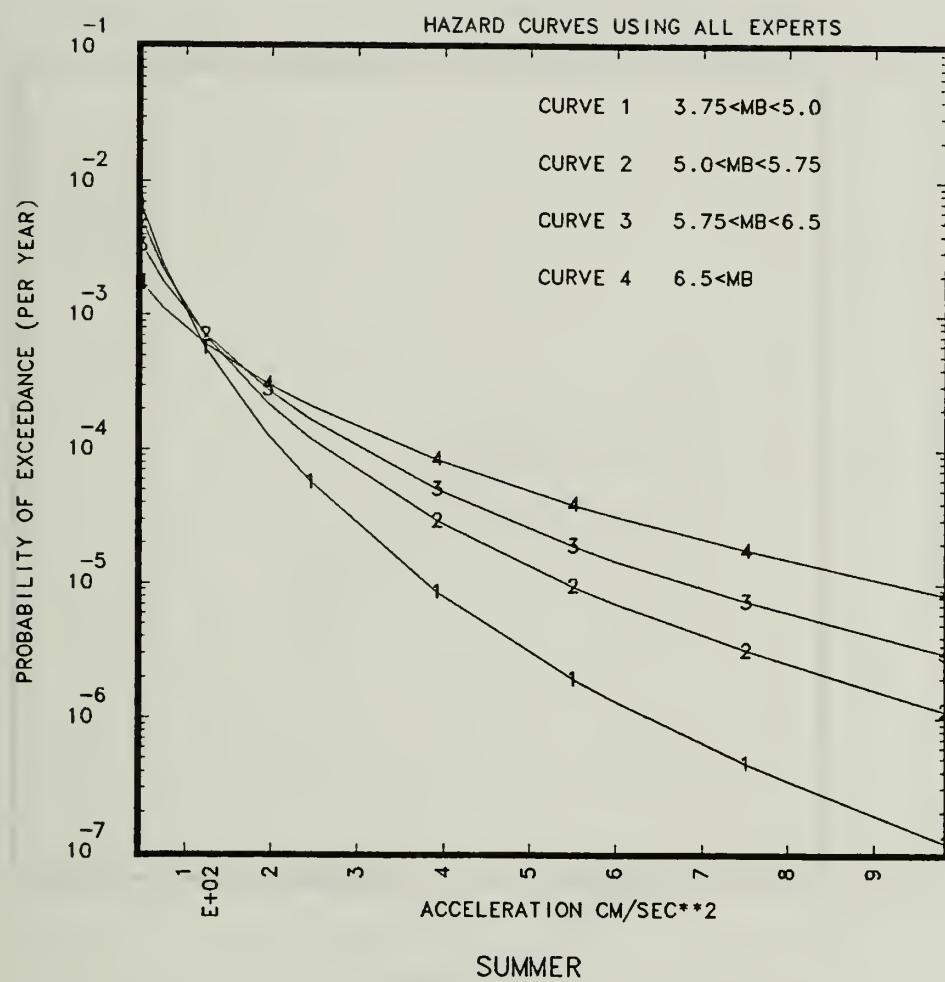


Figure 2.14.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Summer site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

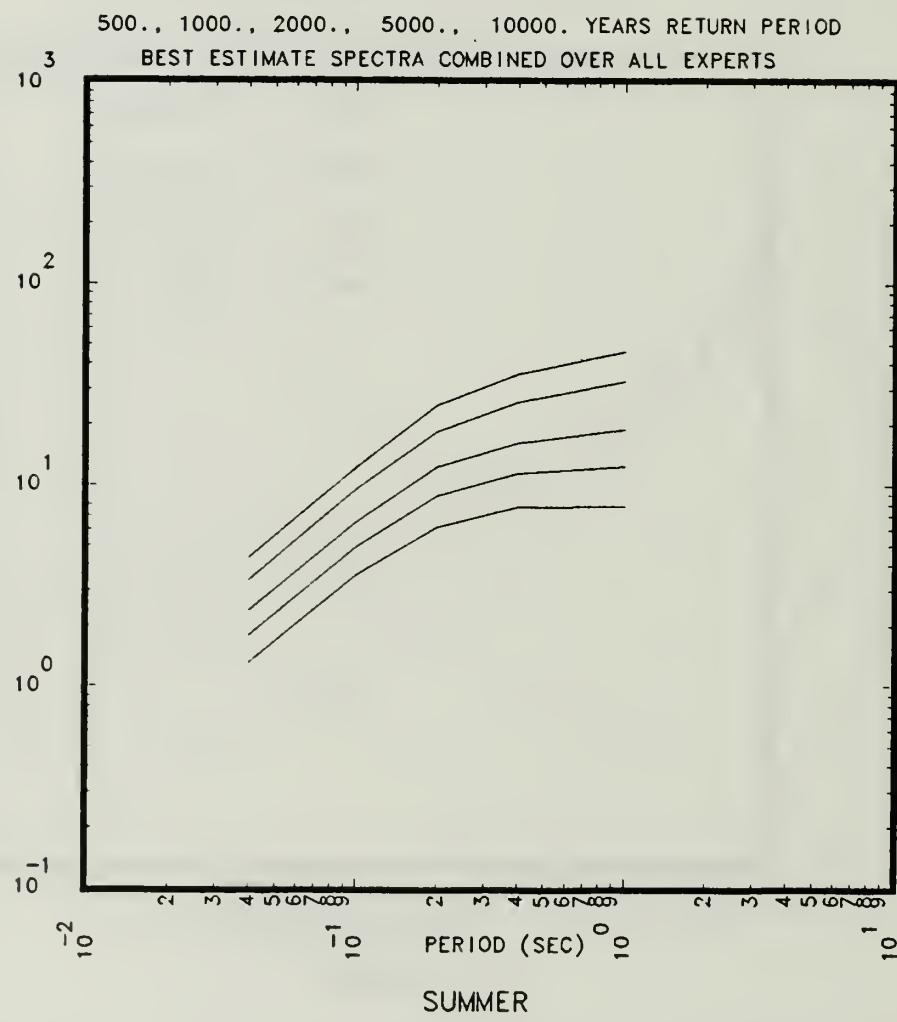


Figure 2.14.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Summer site.

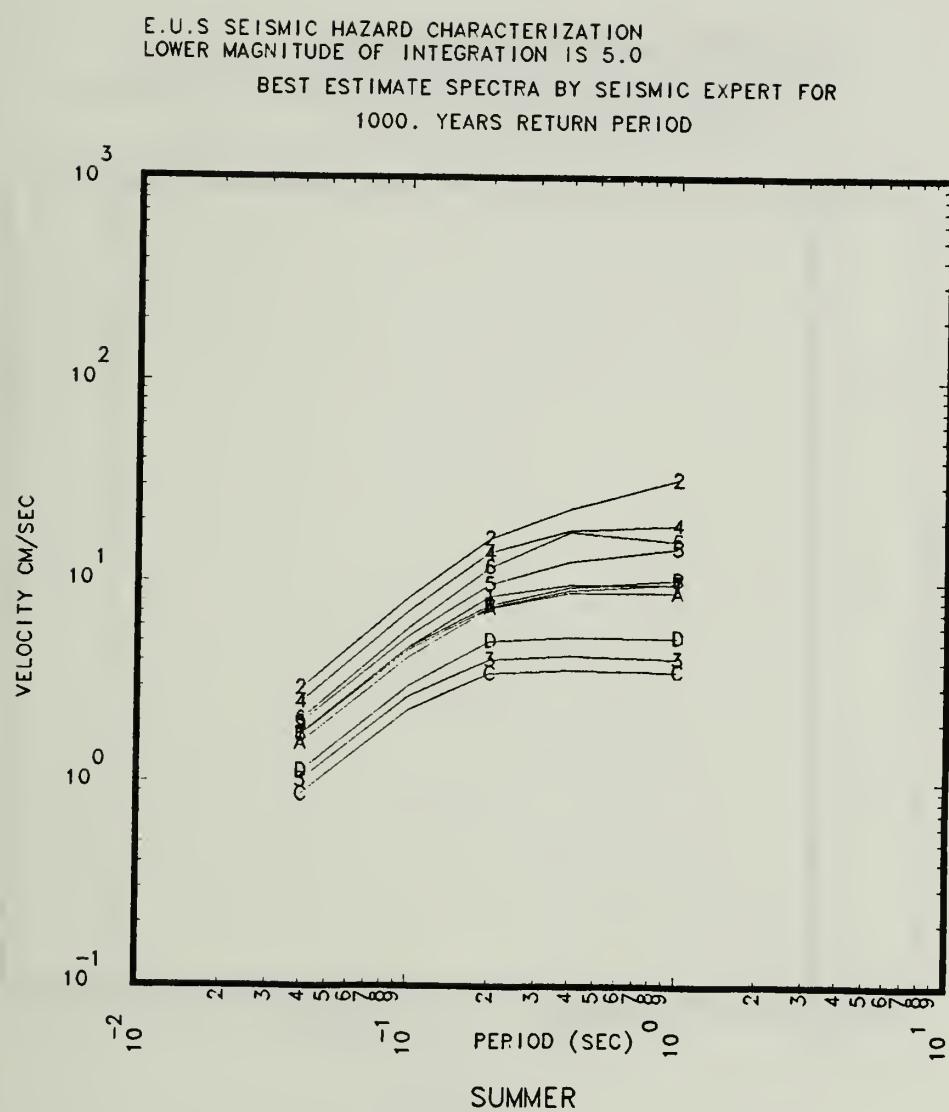


Figure 2.14.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Summer site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

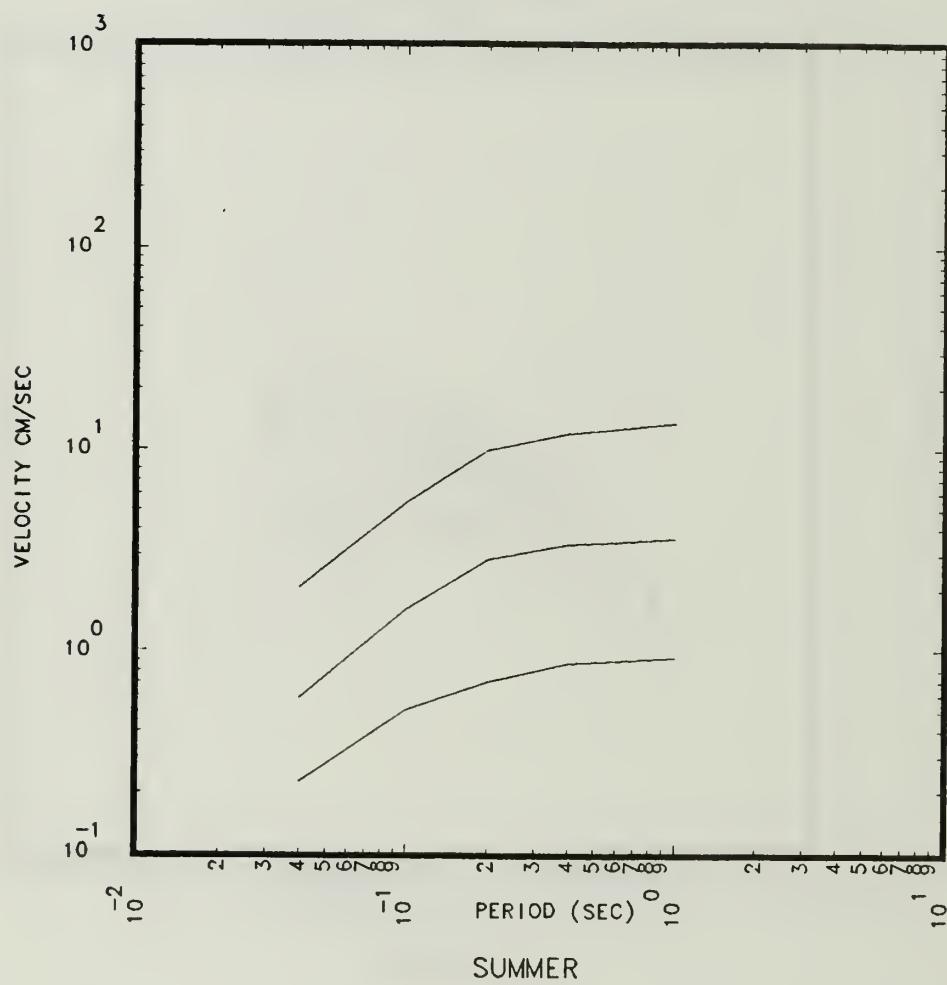


Figure 2.14.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Summer site.

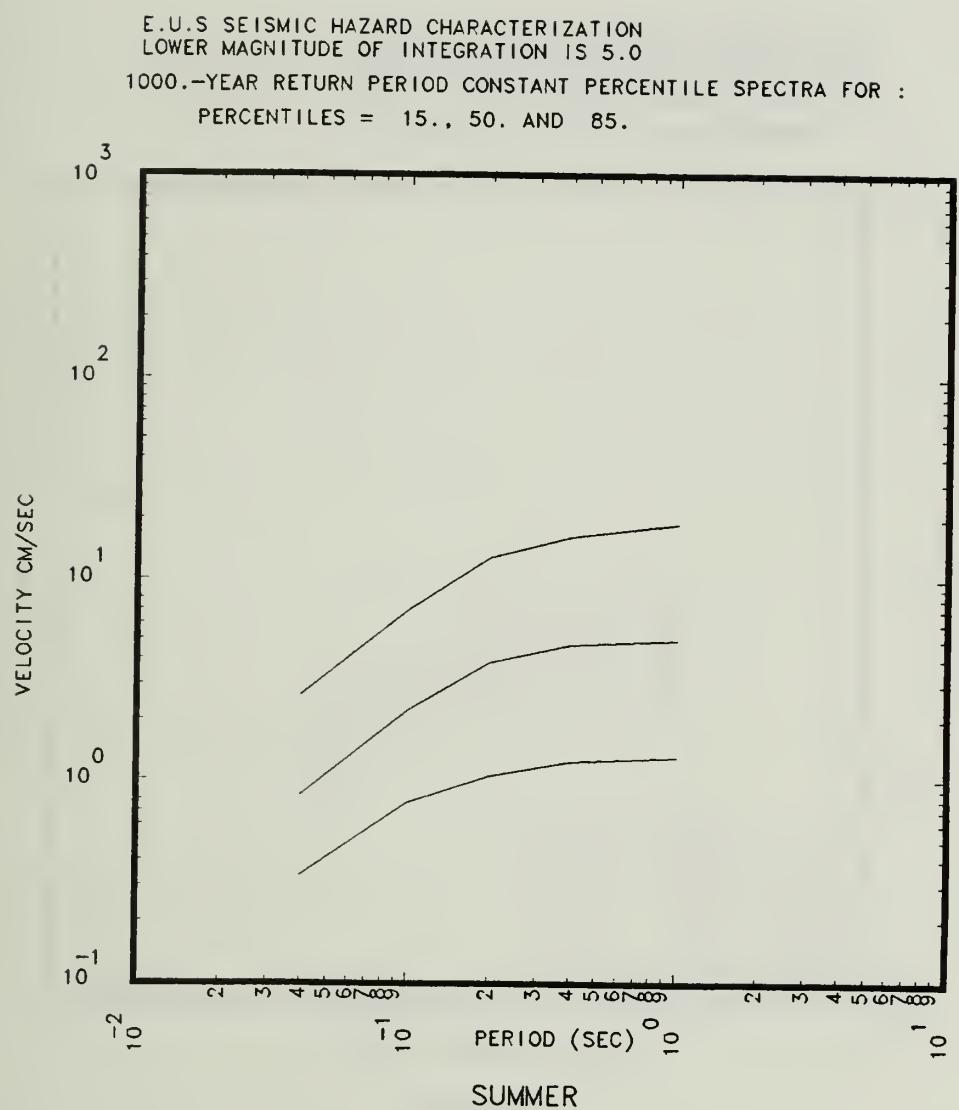


Figure 2.14.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Summer site.

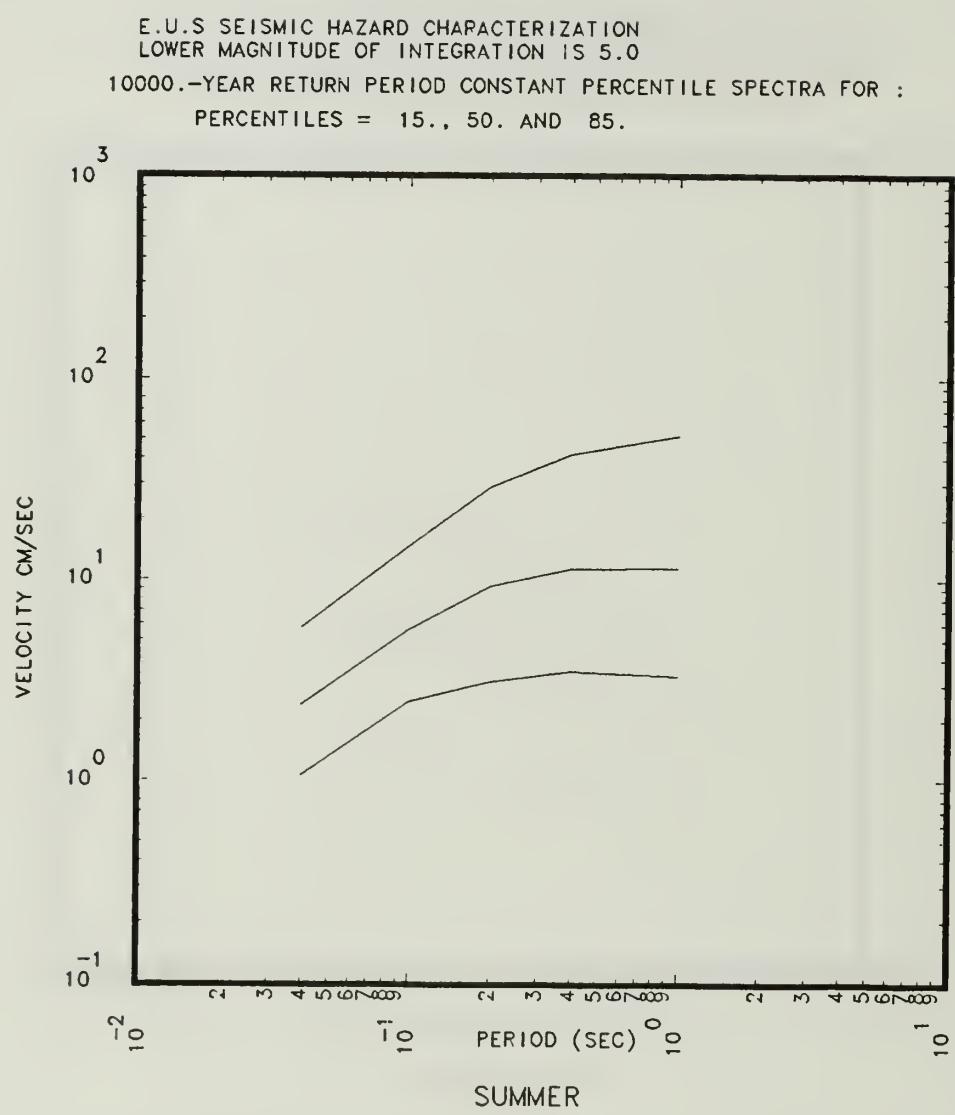


Figure 2.14.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Summer site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

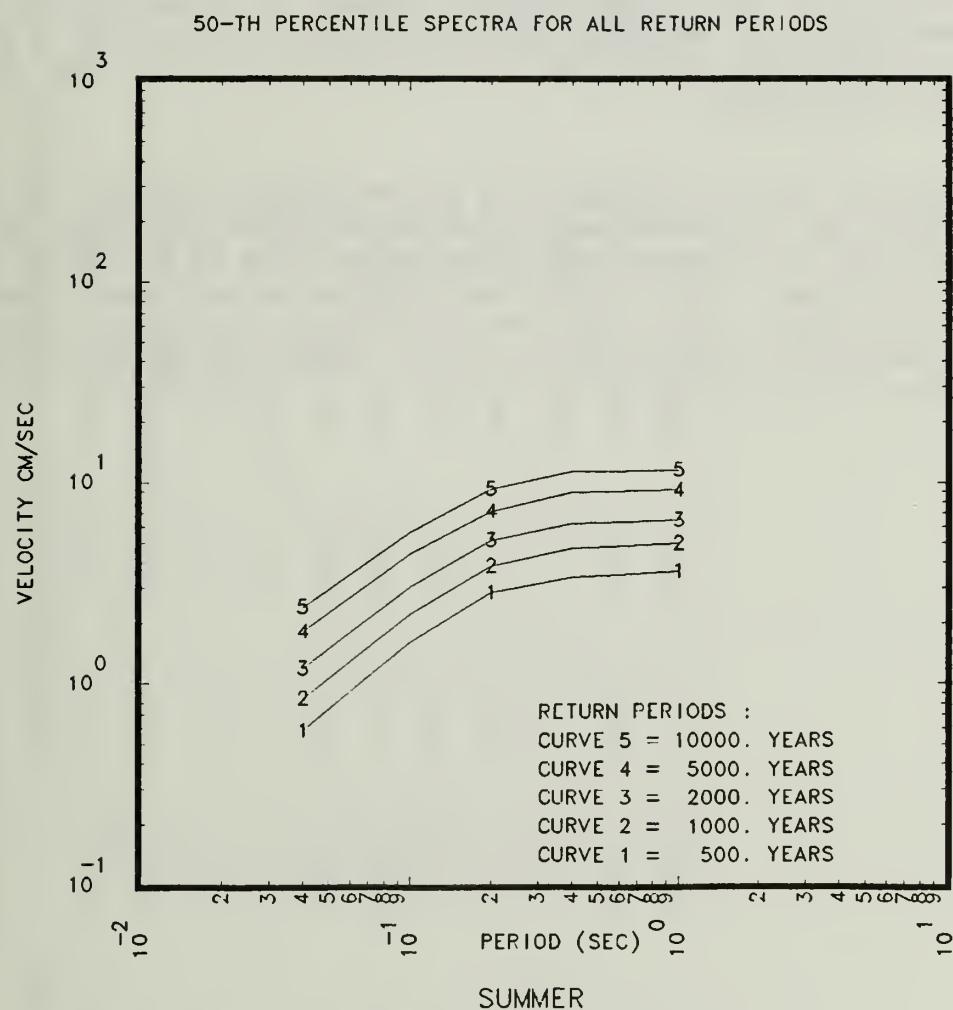


Figure 2.14.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Summer site.

2.15 SURRY

Surry is a deep-soil site represented by the symbol "F" on the location map in Fig. 1.1. Table 2.15.1 and Figs. 2.15.1 to 2.15.10 give the basic results for the Surry site.

The BEHC is close to the median CPHC and the AMHC is relatively close to the 85th percentile CPHC, indicating no important occurrence of high outliers in the sample set of hazard curves.

The diversity of opinions among S-Experts, as displayed by the spread in the BEHC per S-Experts in Fig. 2.15.2, seems to be on the large side. However, if we disregard the curve for S-Expert 4, which appears to be an outlier, the spread becomes typical of the region 2 or even smaller. Similarly, a small spread, for all S-Experts is observed in Fig. 2.15.6 for the 5% damping BEUHS for 1000 year return period.

For most S-Experts, Surry is located in a eastern Seaboard zone of low to medium seismicity and low to medium high magnitude cutoff, and it is far away from high magnitude and high recurrence rate zones, such as New Madrid and Charleston. As a result, Fig. 2.15.4 shows that medium earthquakes (between 5.0 and 5.75 magnitude), and in addition nearby zones (less than 15 km) dominate the hazard, as shown in Fig. 2.15.11. (Note that small earthquakes are not included in Fig. 2.15.11).

TABLE 2.15.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR SURRY

SITE SOIL CATEGORY	DEEP-SOIL	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)			
S-XPT	HOST ZONE NUM.	ZONE 1 % CONT.	ZONE ID: ZONE 4 % CONT.: 84.	ZONE 3 2.	ZONE 2 1.
1	ZONE 1	ZONE 12.	ZONE 12.	ZONE 1 99.	ZONE 3 1.
2	COMP.	ZONE 20 % CONT.	ZONE 30 % CONT.: 45.	ZONE 27 22.	ZONE 28 7.
3	ZONE 8A	ZONE ID: ZONE 8A % CONT.	ZONE 6 90.	ZONE 5 2.	ZONE 9 0.
4	COMP.	ZONE 20 % CONT.	ZONE 10 % CONT.: 51.	ZONE 8 17.	ZONE 11 10.
5	ZONE 8	ZONE ID: ZONE 8 % CONT.	ZONE 9 54.	ZONE 1 38.	ZONE 10 1.
6	COMP.	ZONE 20 % CONT.	ZONE 15 52.	ZONE 6 20.	ZONE 13 19.
7	ZONE 9	ZONE ID: ZONE 9 % CONT.	ZONE 2 = ZONE 10 89.	ZONE 7 4.	ZONE 9 2.
10	ZONE 4B	ZONE ID: ZONE 4B % CONT.	ZONE 19 = ZONE 15 98.	ZONE 28A 1.	ZONE 4B 0.
11	CZ = ZON	ZONE ID: ZONE 8 % CONT.	CZ = ZONE ZONE 5 54.	ZONE 7 40.	ZONE 8 1.
12	ZONE 32	ZONE ID: ZONE 32 % CONT.	ZONE 22 95.	ZONE 23A 4.	ZONE 19 0.
13	CZ 17	ZONE ID: CZ 17 % CONT:	CZ 98. 1.	ZONE 9 1.	CZ 15 1.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

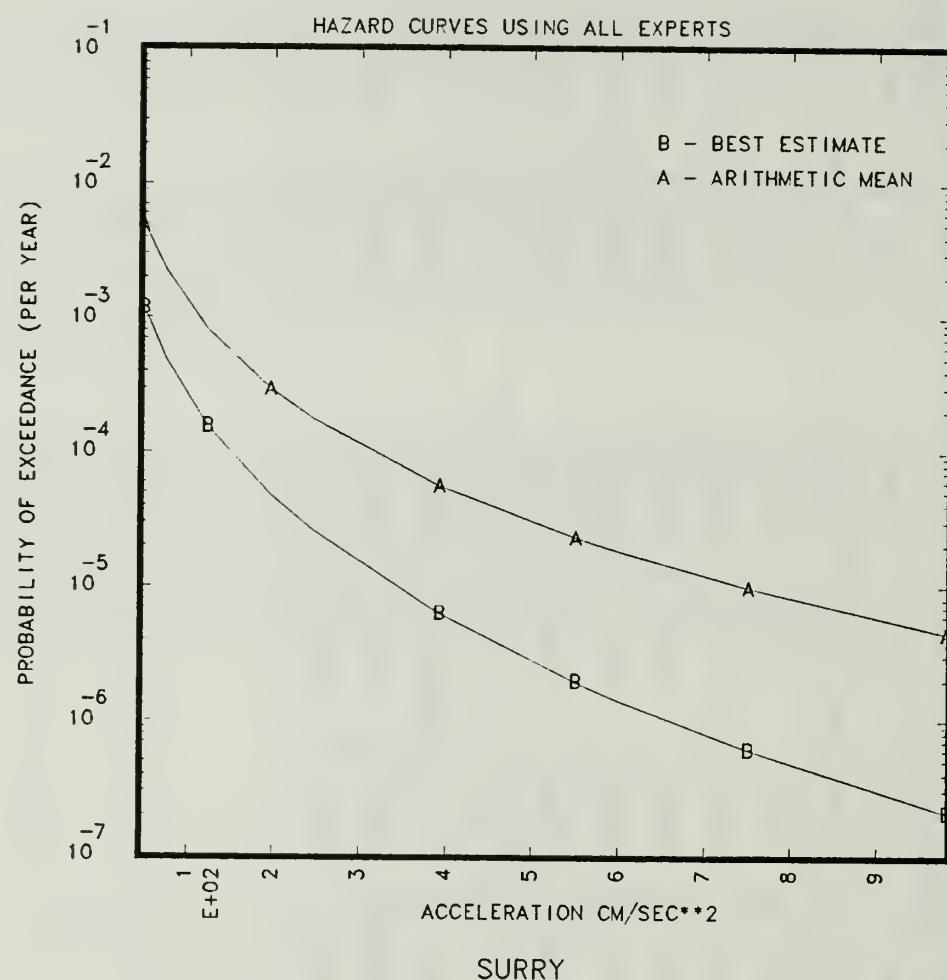


Figure 2.15.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Surry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

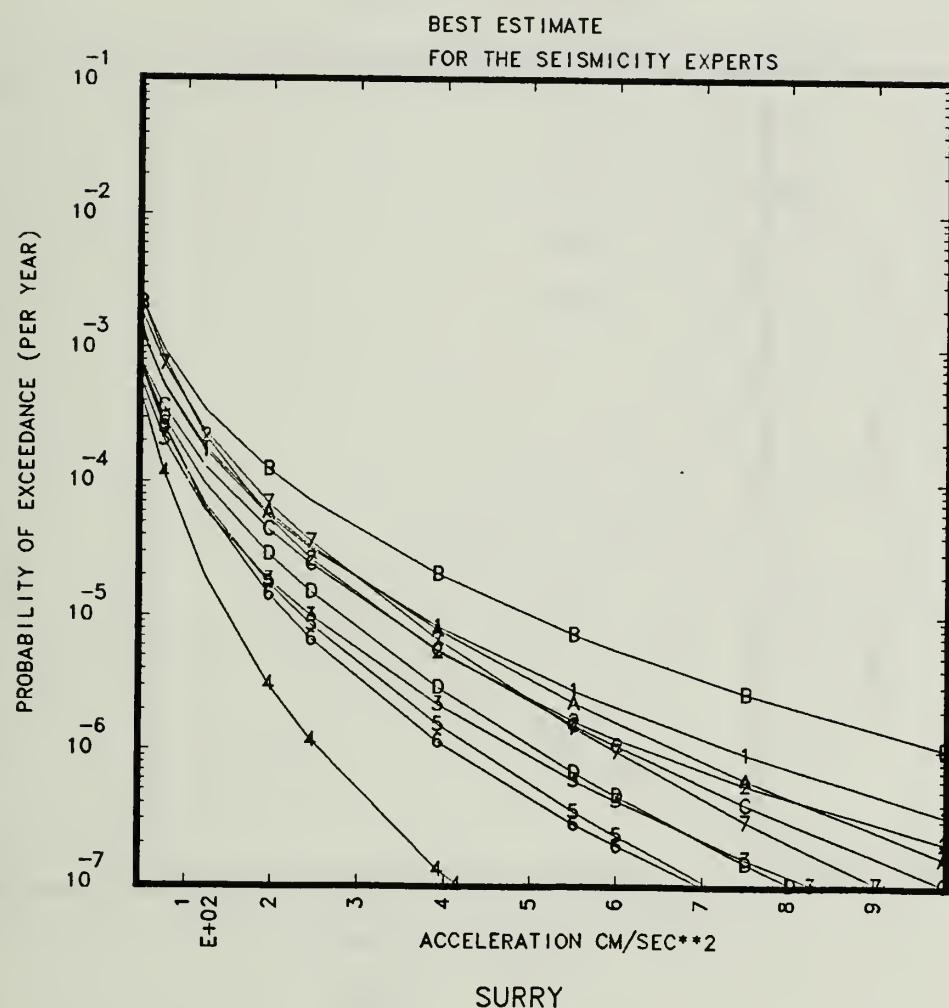


Figure 2.15.2 BEHCs per S-Expert combined over all G-Experts for the Surry site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

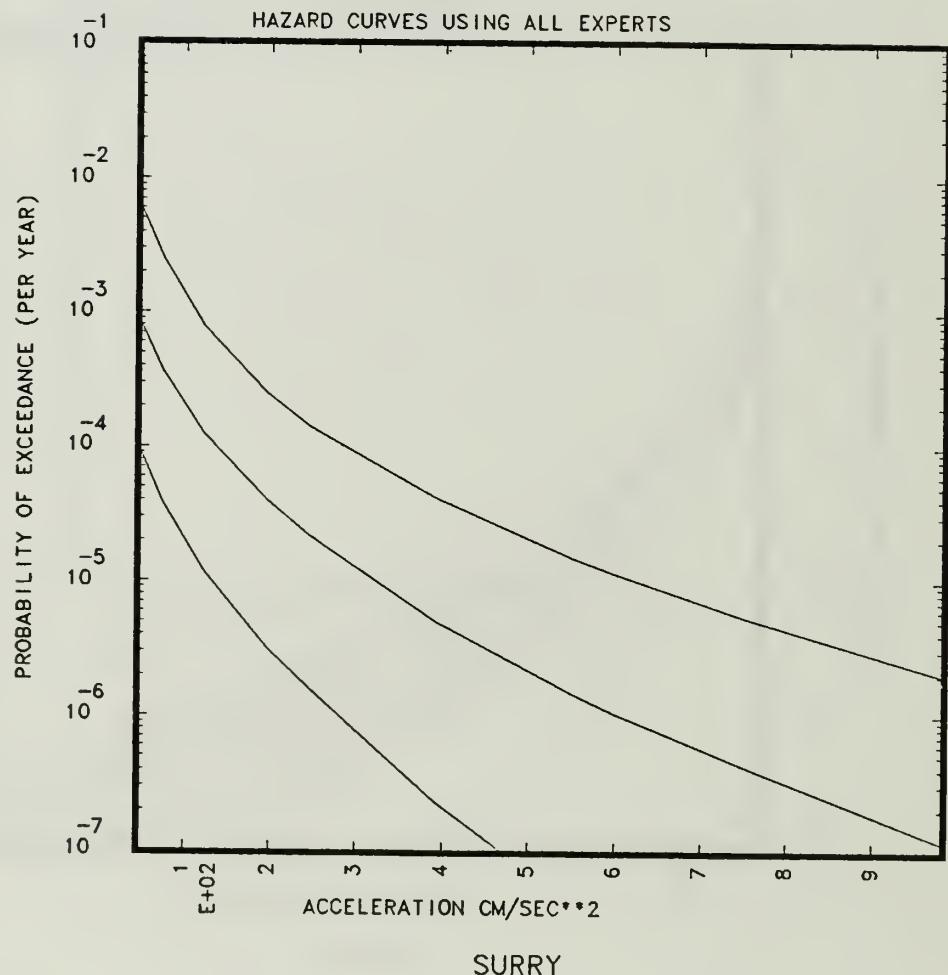


Figure 2.15.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Surry site.

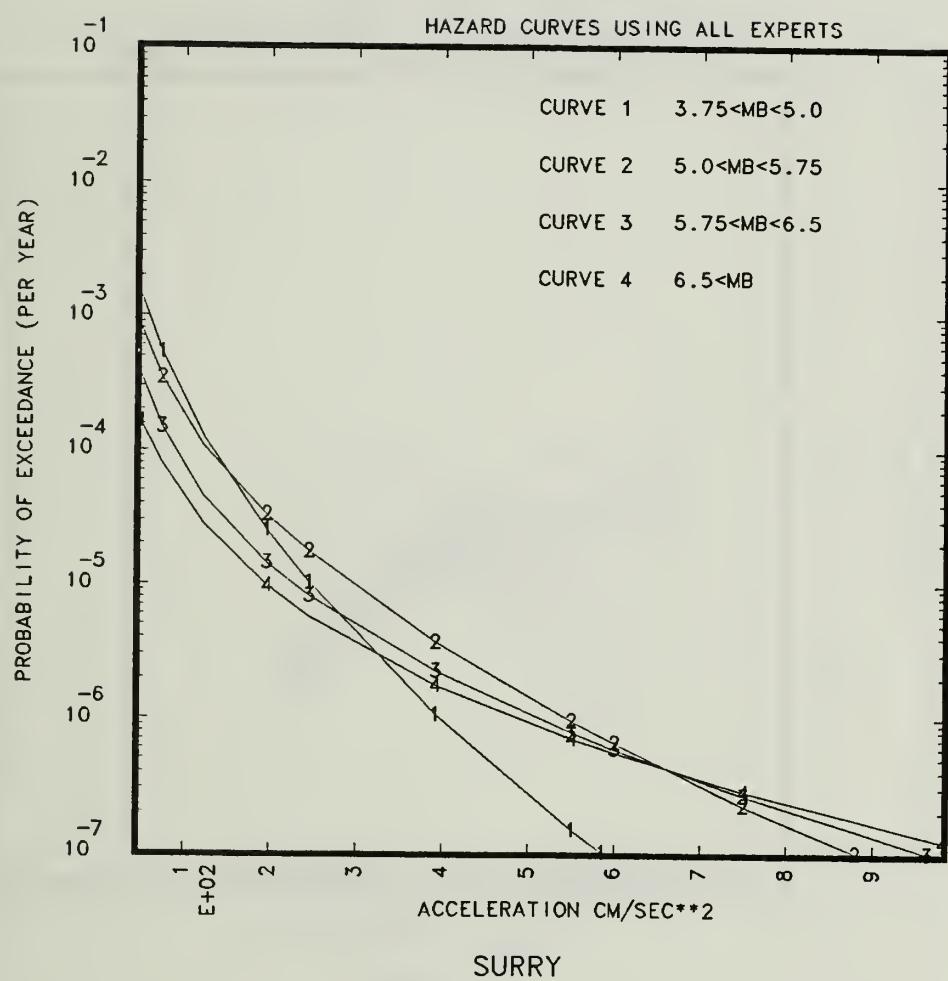


Figure 2.15.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Surry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

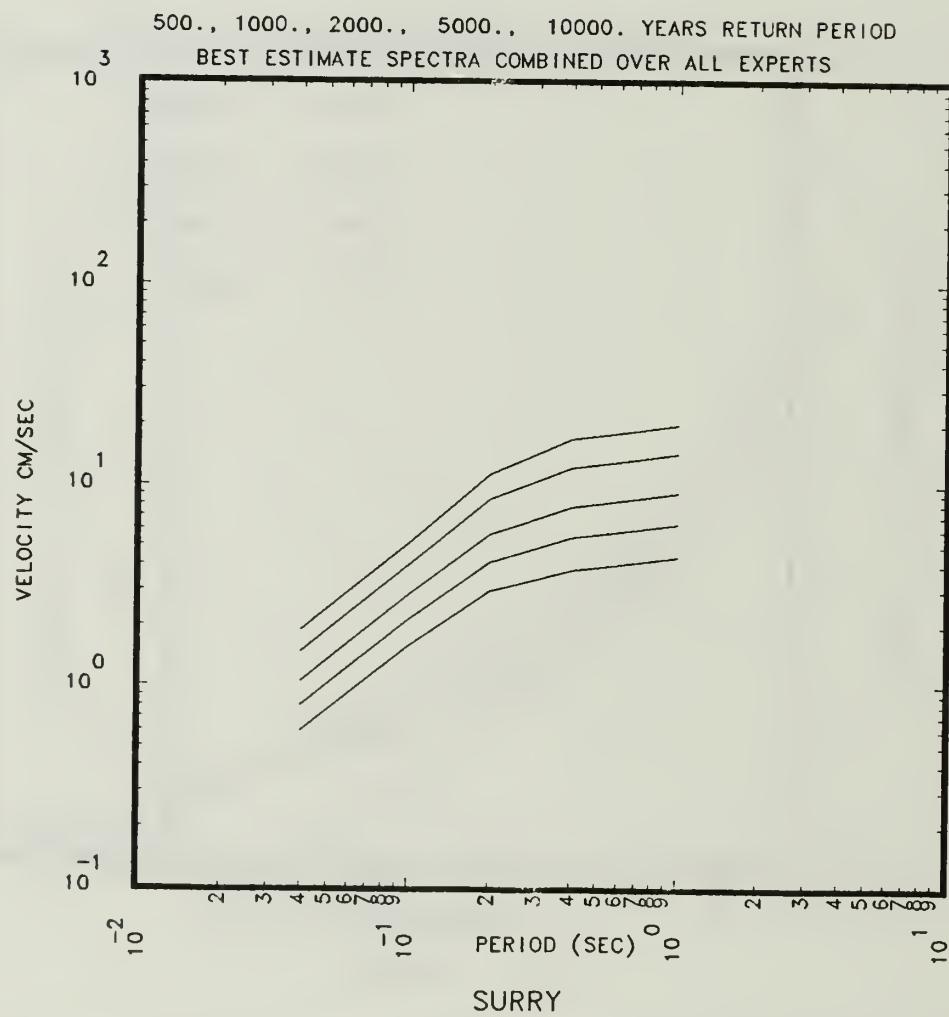


Figure 2.15.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Surry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
BEST ESTIMATE SPECTRA BY SEISMIC EXPERT FOR
1000. YEARS RETURN PERIOD

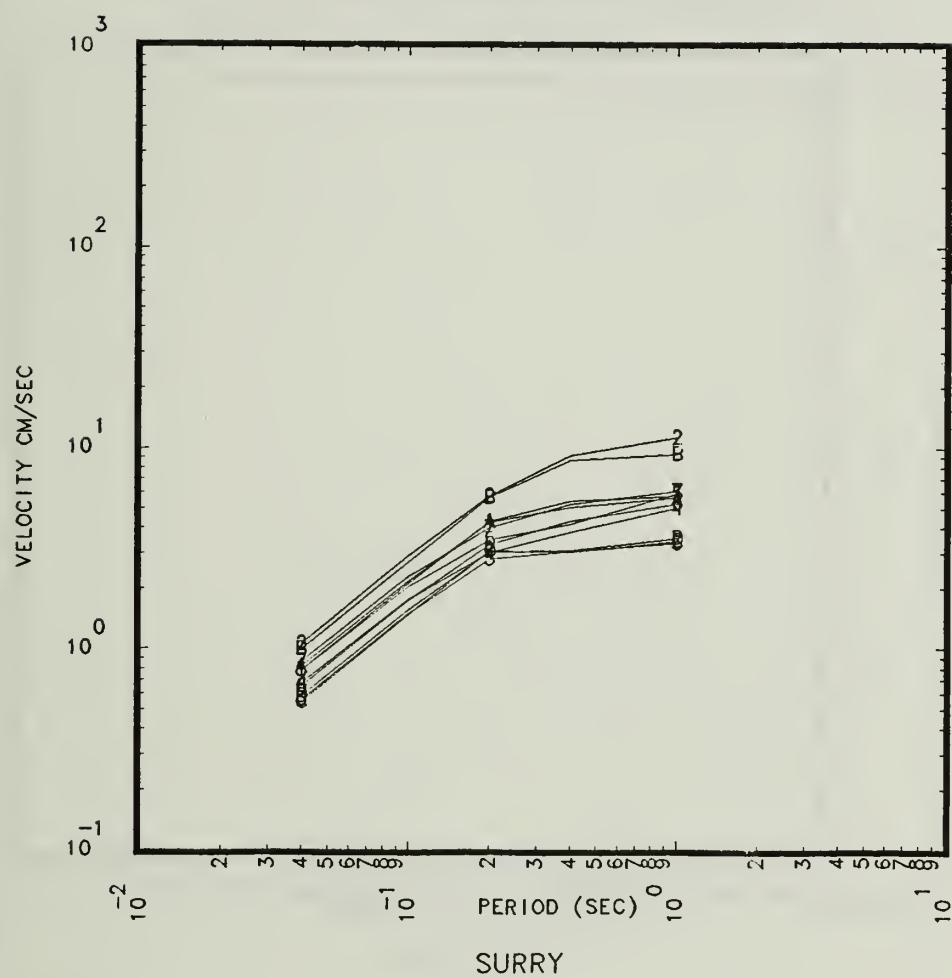


Figure 2.15.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Surry site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

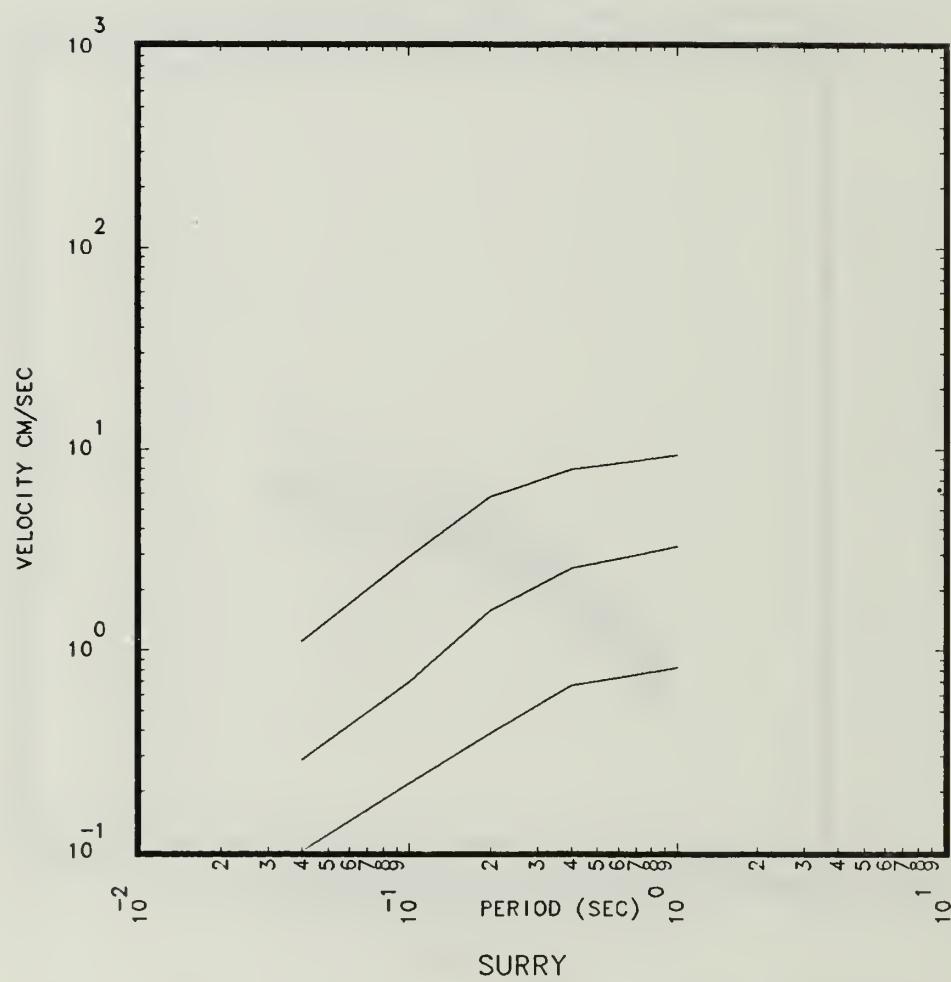


Figure 2.15.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Surry site.

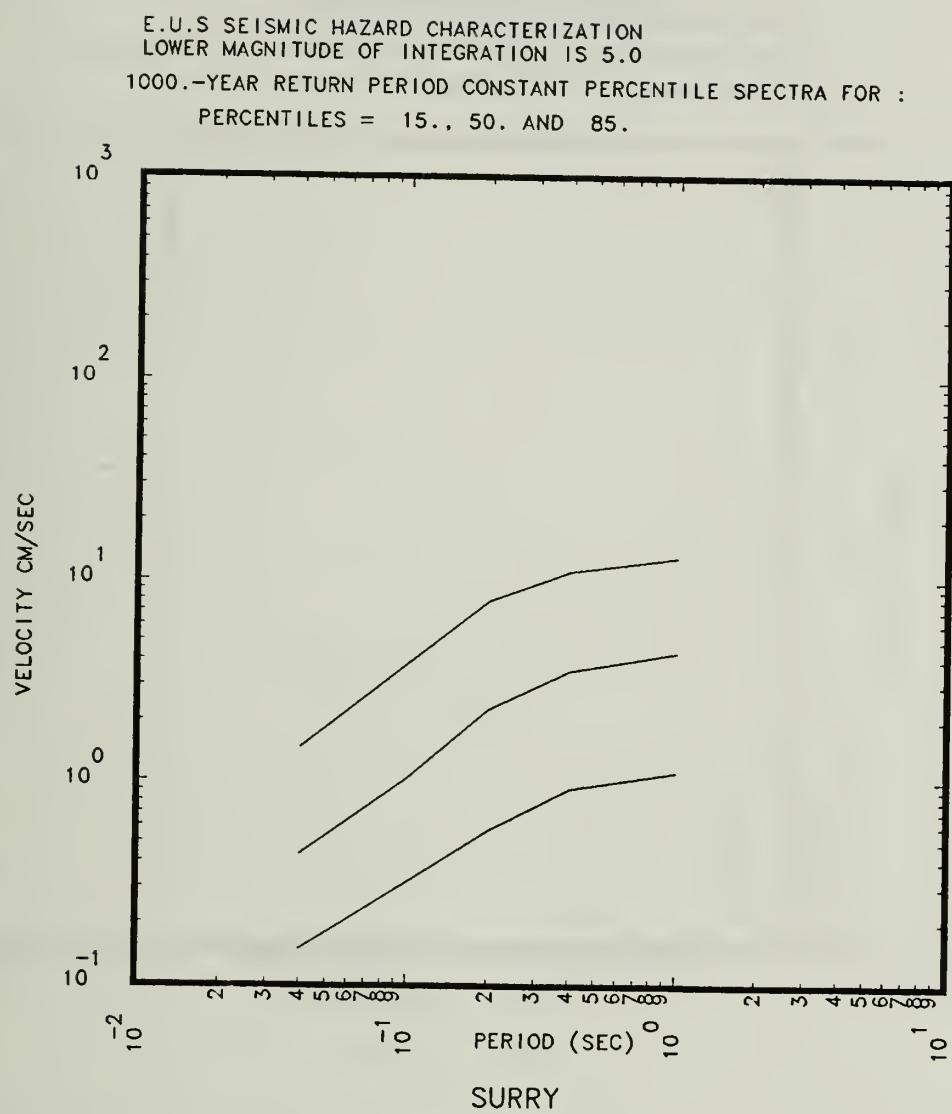


Figure 2.15.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Surry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

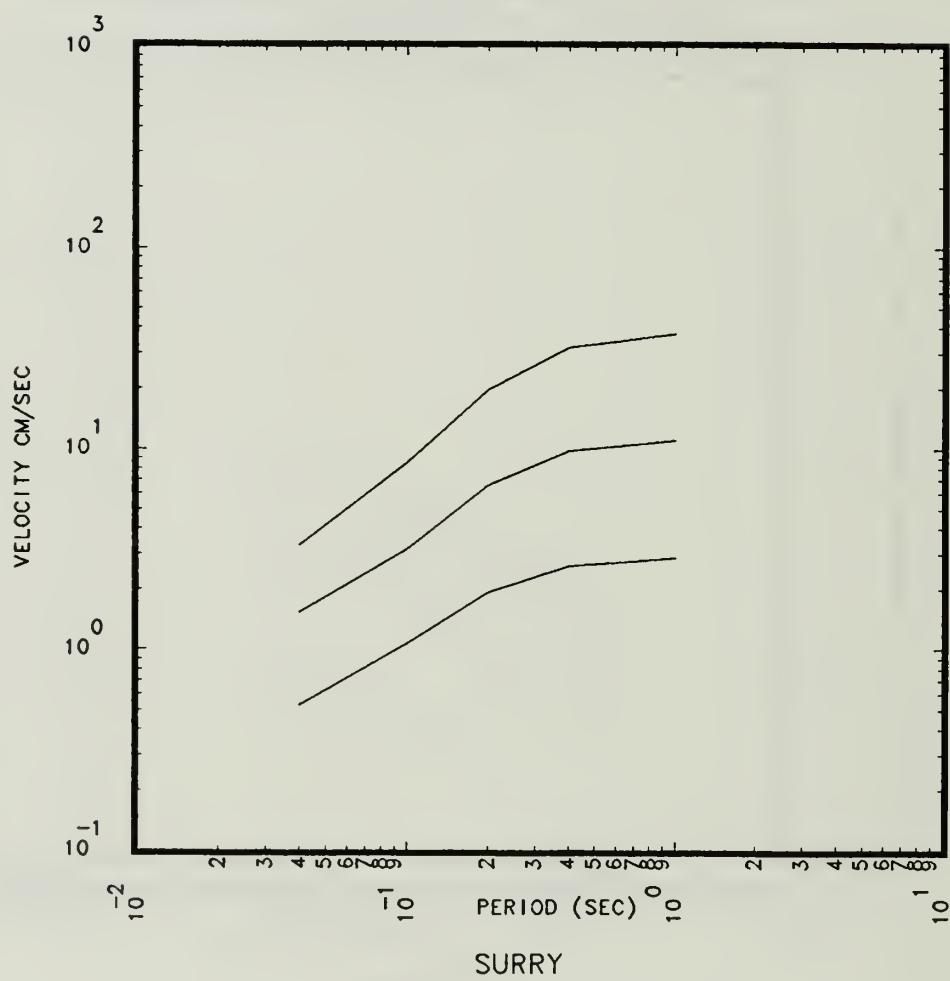


Figure 2.15.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Surry site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

50-TH PERCENTILE SPECTRA FOR ALL RETURN PERIODS

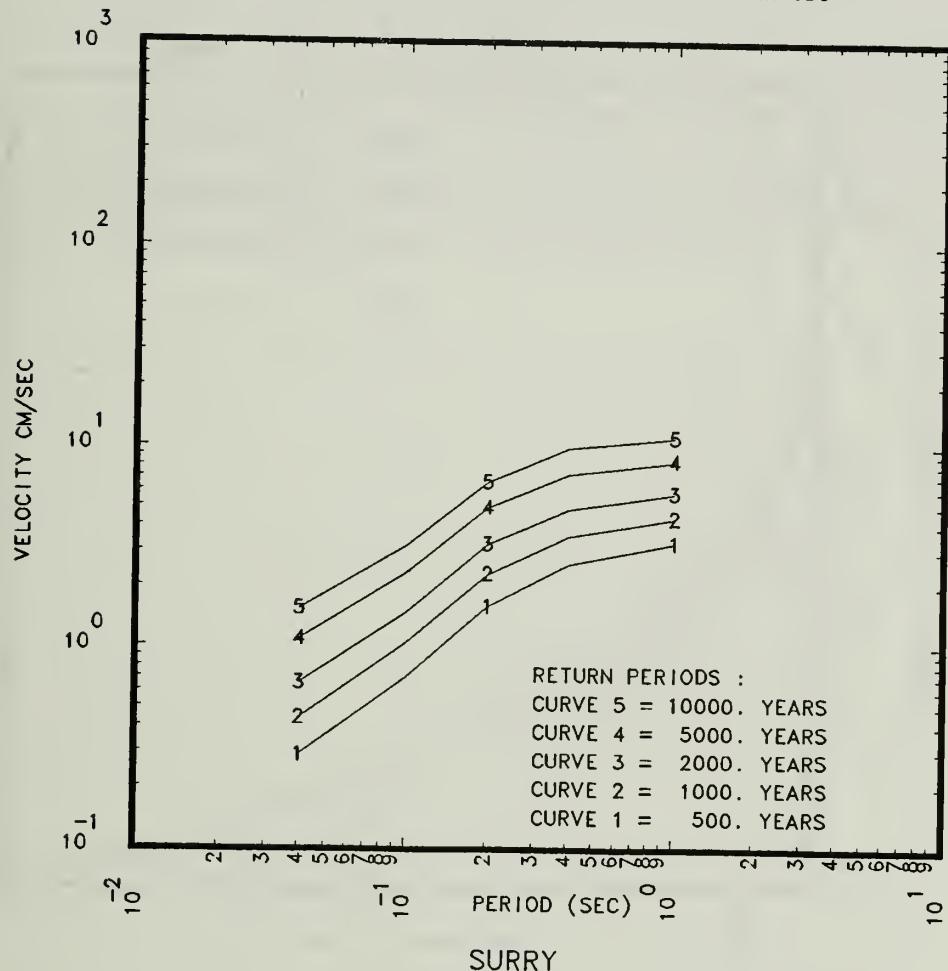


Figure 2.15.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Surry site.

CONTRIBUTION TO THE HAZARD FOR PGA
FROM THE EARTHQUAKES IN 4 DISTANCE RANGES

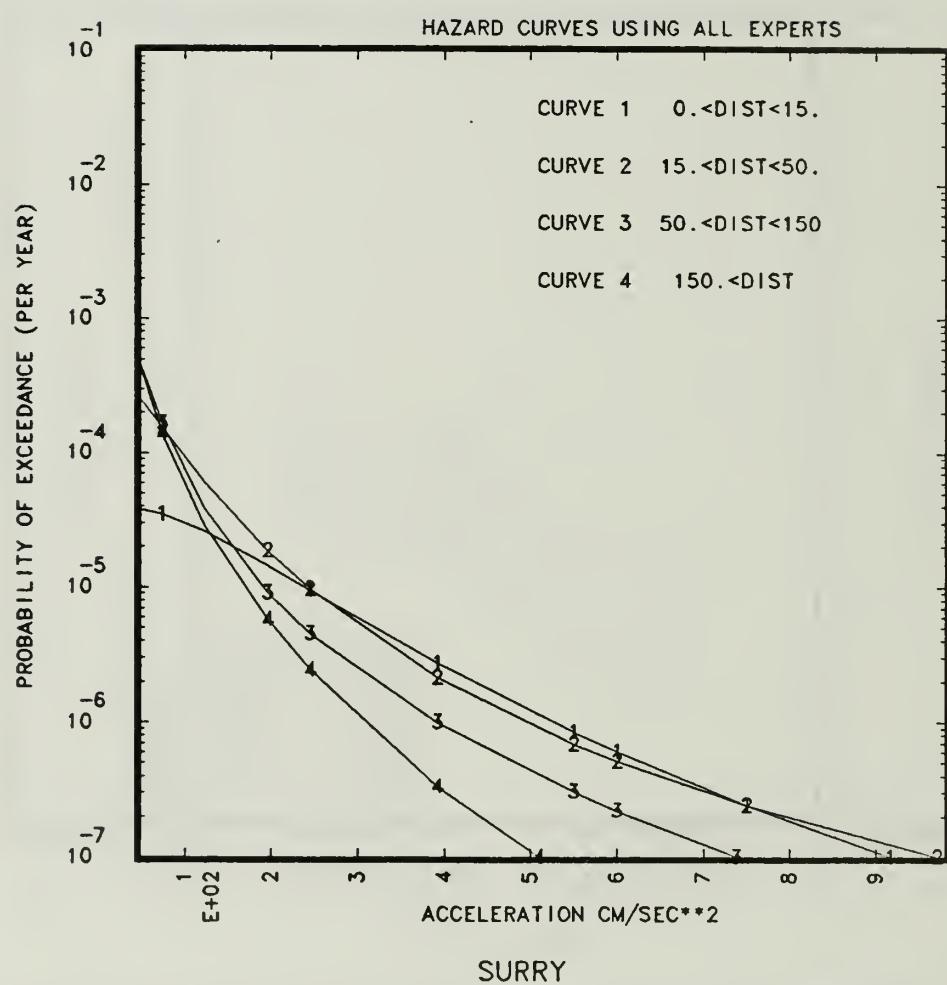


Figure 2.15.11 Contribution for ranges of distance of earthquakes from the Surry site for all earthquakes greater than magnitude 5.0.

2.16 VOGTLE

Vogtle is a deep soil site represented by the symbol "G" on the location map in Fig. 1.1. Table 2.16.1 and Figs. 2.16.1 to 2.16.10 give the basic results for the Vogtle site.

The AMHC is up to a factor of 4 higher than the 85th percentile CPHC, indicating the presence of high outliers in the sample set of hazard curves generated in the Monte Carlo simulation (see Vol. I, Section 2.3 for details on the methodology).

The diversity of opinions in the S-Expert, for this site, as displayed by the spread in the S-Experts' BEHC in Fig. 2.16.2 is rather typical of region 2 (southeastern U.S.) perhaps a little bit bigger. Vogtle is relatively close to the Charleston area and Table 2.16.1 shows that for all but S-Expert 10, the dominant zone, by and large, is the localized Charleston seismic zone, and as a result most of the hazard comes from distances greater than 50 km, and from large earthquakes (greater and magnitude 6.5), as shown in Fig. 2.16.3. Figure 2.16.3 also shows that, for this site, the small earthquakes contribute very little to the hazard, except at very low PGA values.

TABLE 2.16.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR VGGTE

SITE SOIL CATEGORY	DEEP-SOIL	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)
S-XPT NUM. ZONE	HOST ZONE	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT HIGH PGA(0.60G)
1 ZONE 1	ZONE ID: ZONE 2 % CONT.: 49.	ZONE 1 ZONE 9 ZONE 3 ZONE 9 ZONE 8.
2 ZONE 29	ZONE ID: ZONE 30 % CONT.: 74.	ZONE 29 ZONE 22. ZONE 4. ZONE 0.
3 ZONE 8	ZONE ID: ZONE 9 % CONT.: 84.	ZONE 8 ZONE 12. ZONE 4. ZONE 0.
4 ZONE 25	ZONE ID: ZONE 10 % CONT.: 88.	ZONE 9 ZONE 8. ZONE 4. ZONE 0.
5 ZONE 8	ZONE ID: ZONE 9 % CONT.: 91.	ZONE 10 ZONE 6. ZONE 2. ZONE 1.
6 ZONE 13	ZONE ID: ZONE 13 % CONT.: 99.	ZONE 14 ZONE 1. ZONE 11 ZONE 0.
7 ZONE 8	ZONE ID: ZONE 10 % CONT.: 67.	ZONE 8 ZONE 21. ZONE 6. ZONE 10.
10 ZONE 4B	ZONE ID: ZONE 4B % CONT.: 46.	ZONE 15 ZONE 44. ZONE 10. ZONE 10.
11 ZONE 8	ZONE ID: ZONE 8 % CONT.: 95.	ZONE 7 ZONE 11 CZ = ZONE 0.
12 ZONE 23	ZONE ID: ZONE 23 % CONT.: 53.	ZONE 24 ZONE 42. ZONE 3. ZONE 2.
13 CZ 17	ZONE ID: ZONE 69 % CONT.: 64.	CZ 17 CZ 34. ZONE 1. ZONE 1.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

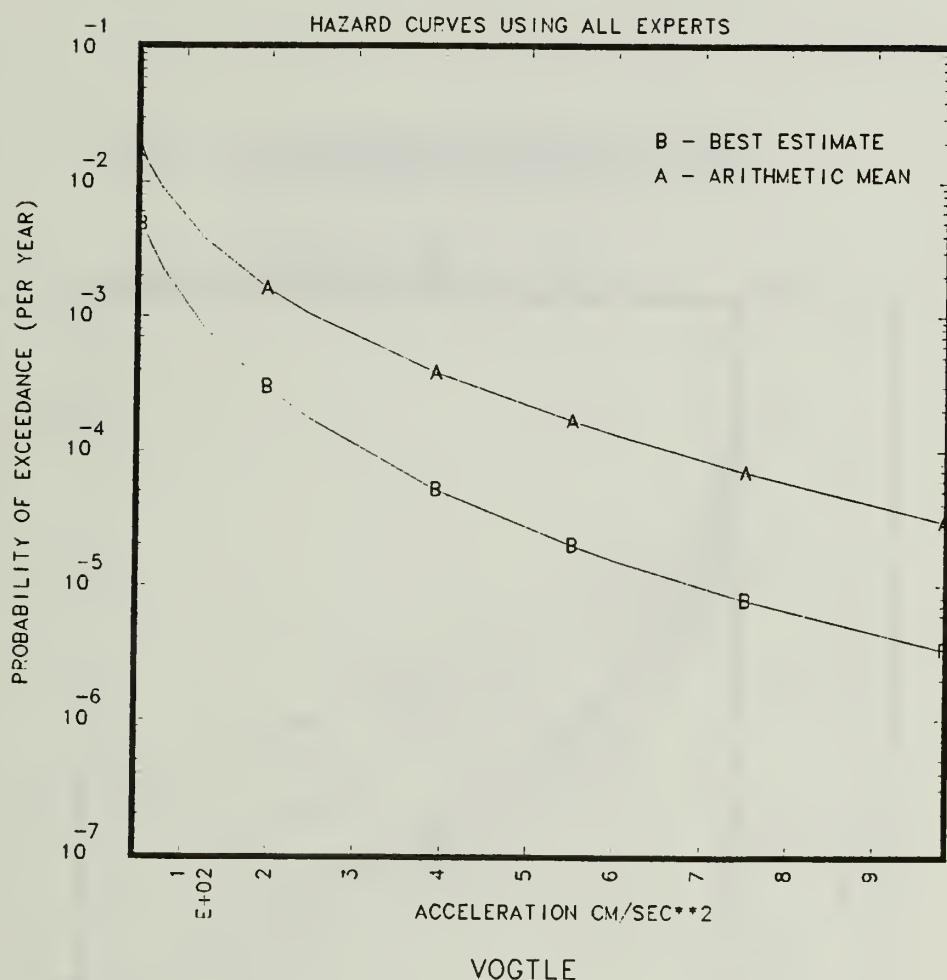


Figure 2.16.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Vogtle site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

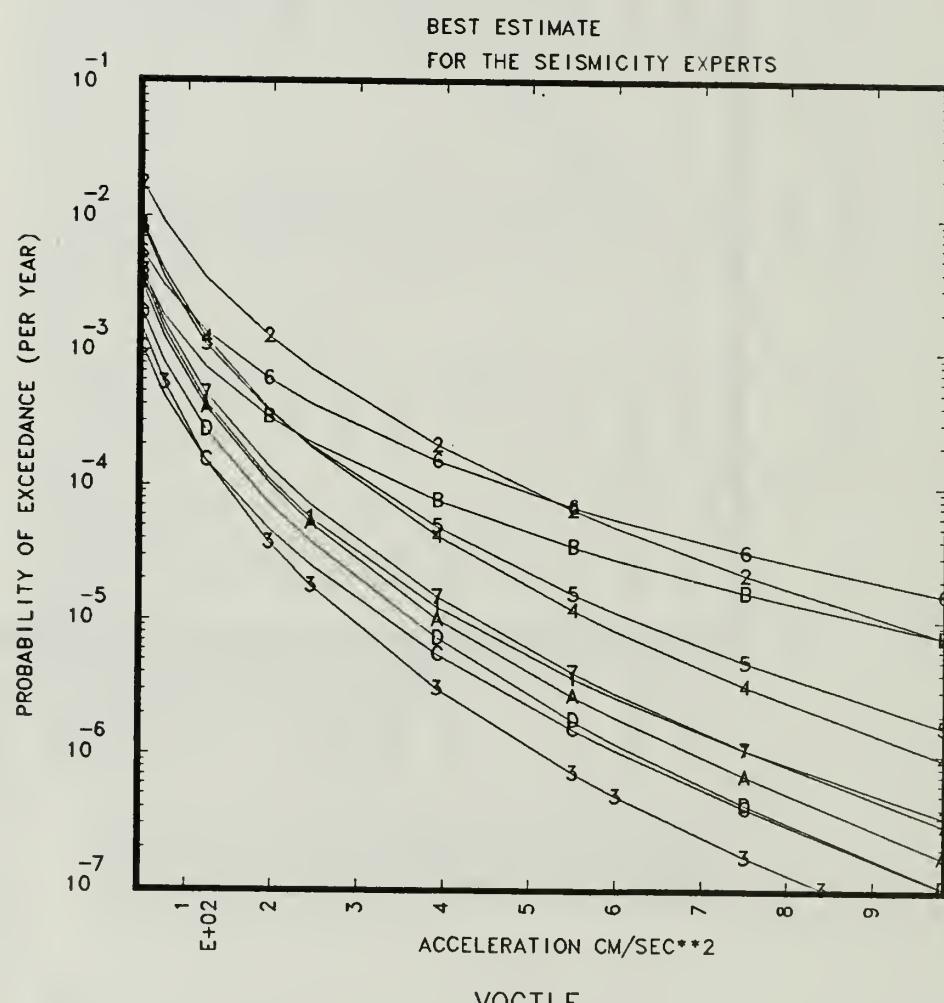


Figure 2.16.2 BEHCs per S-Expert combined over all G-Experts for the Vogtle site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

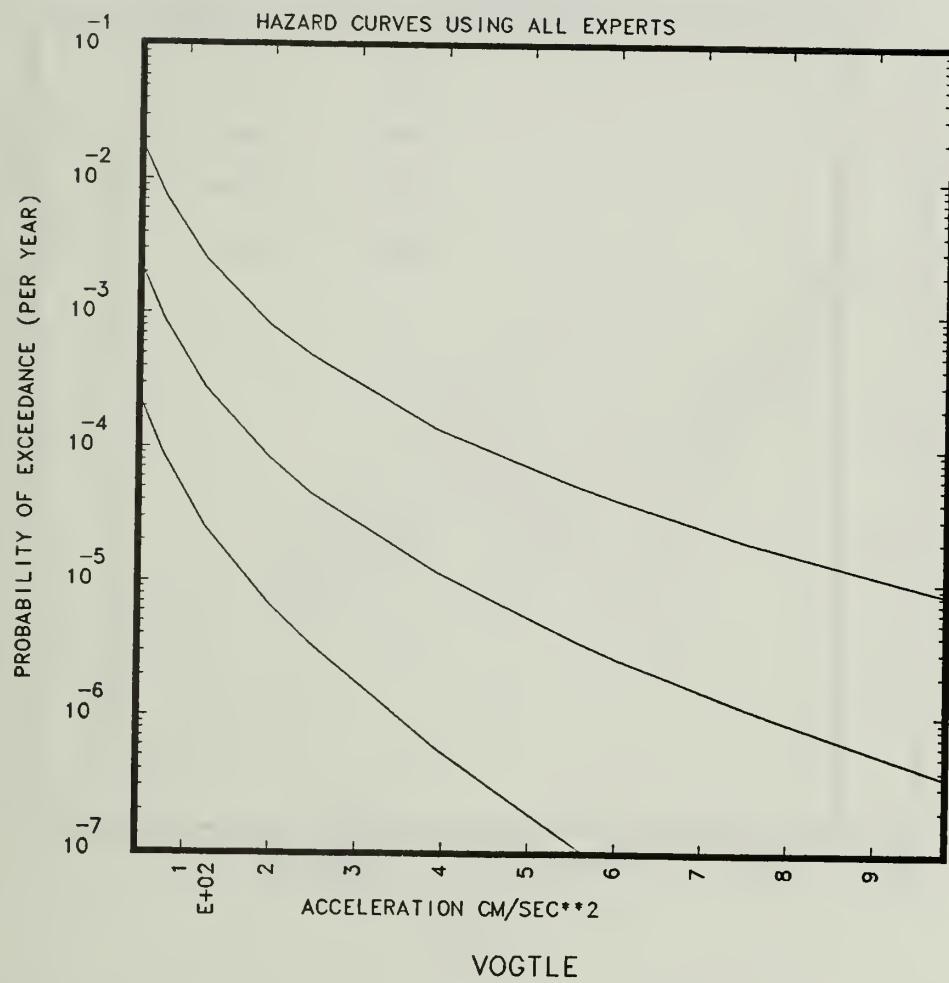
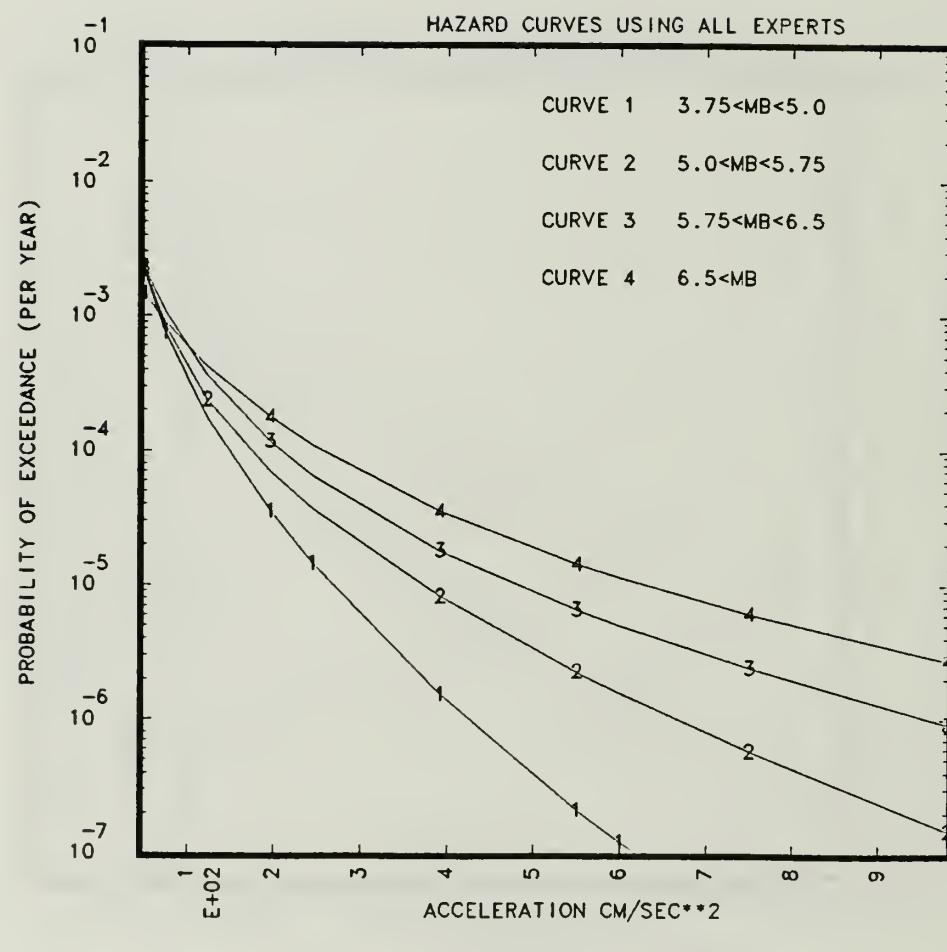


Figure 2.16.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Vogtle site.



VOGTLE

Figure 2.16.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Vogtle site.

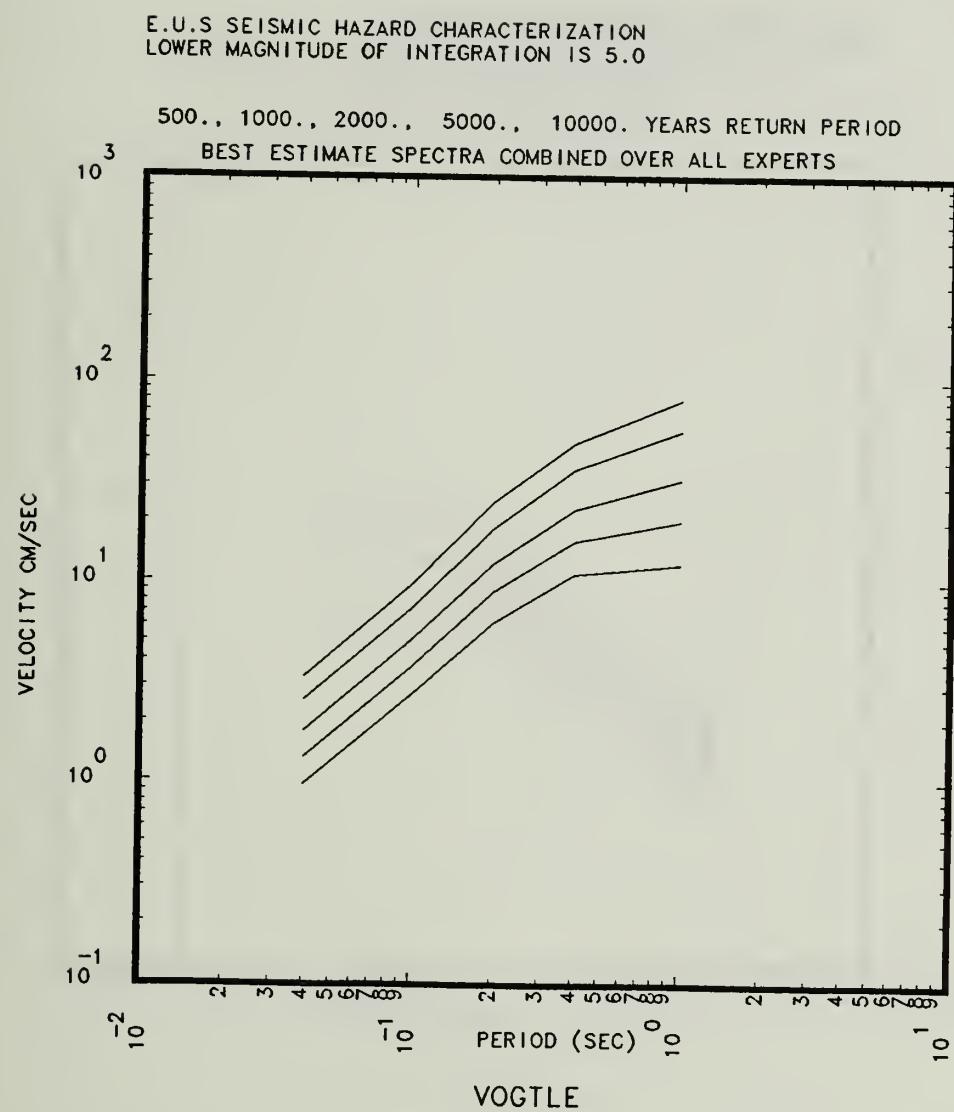


Figure 2.16.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Vogtle site.

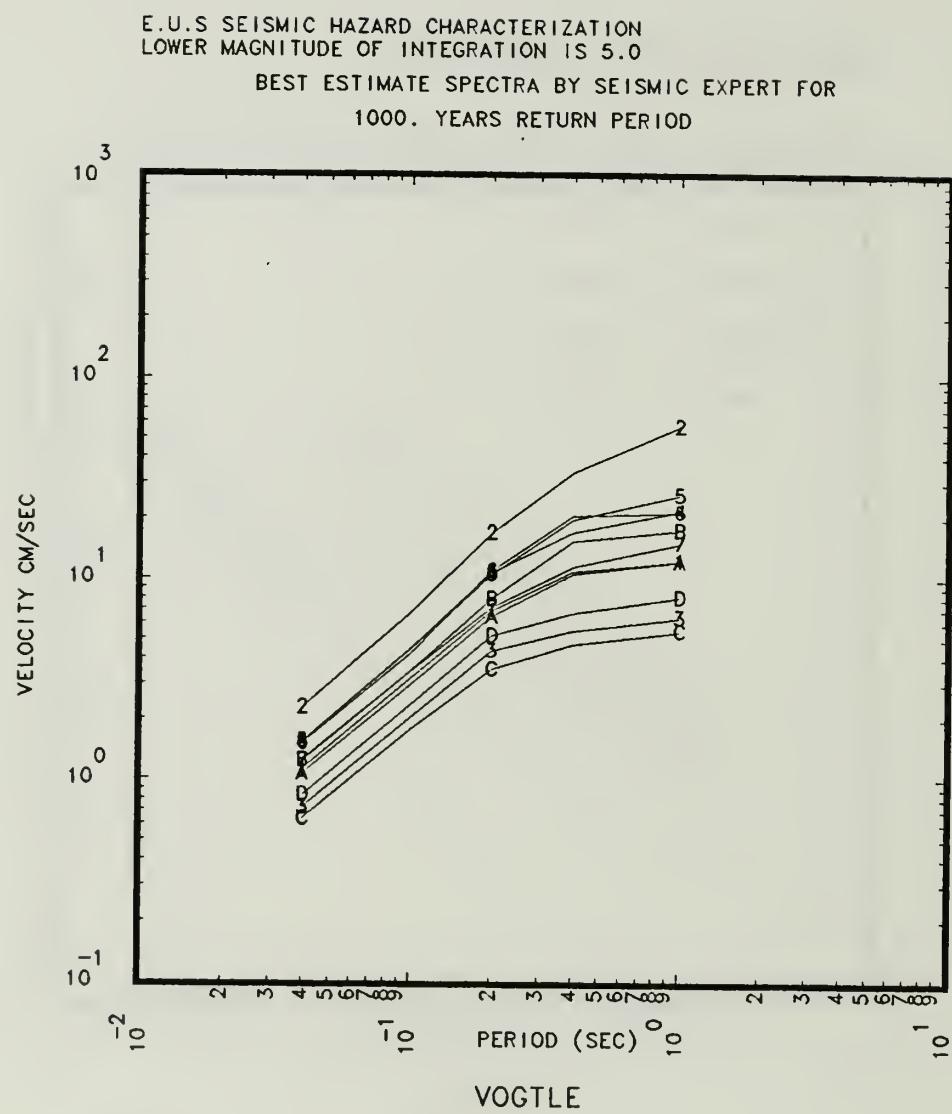


Figure 2.16.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Vogtle site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

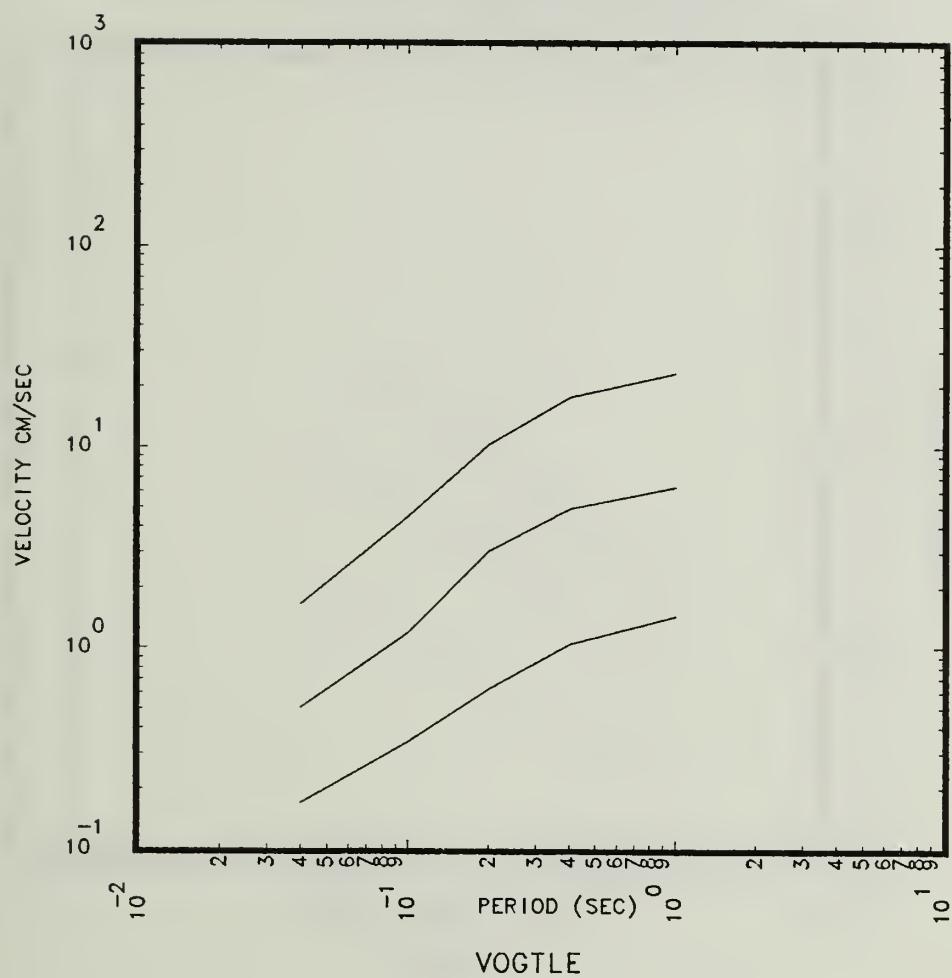


Figure 2.16.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Vogtle site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
1000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

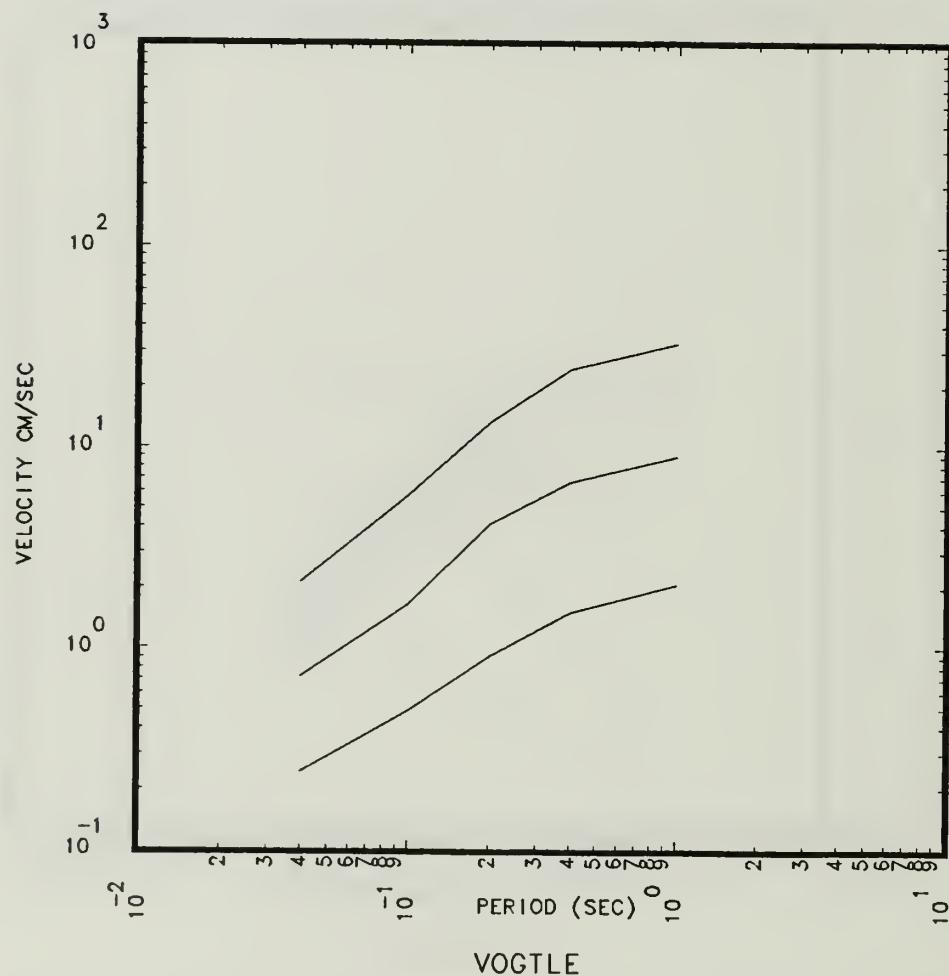


Figure 2.16.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Vogtle site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

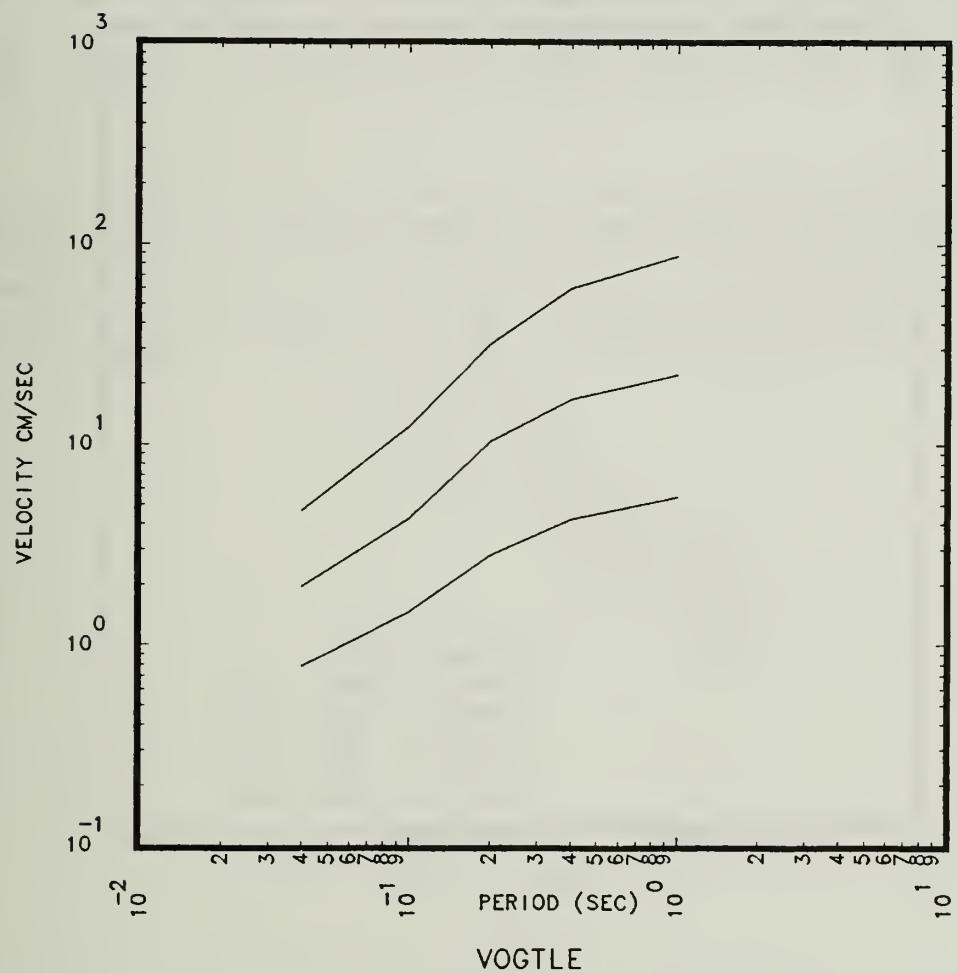


Figure 2.16.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Vogtle site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

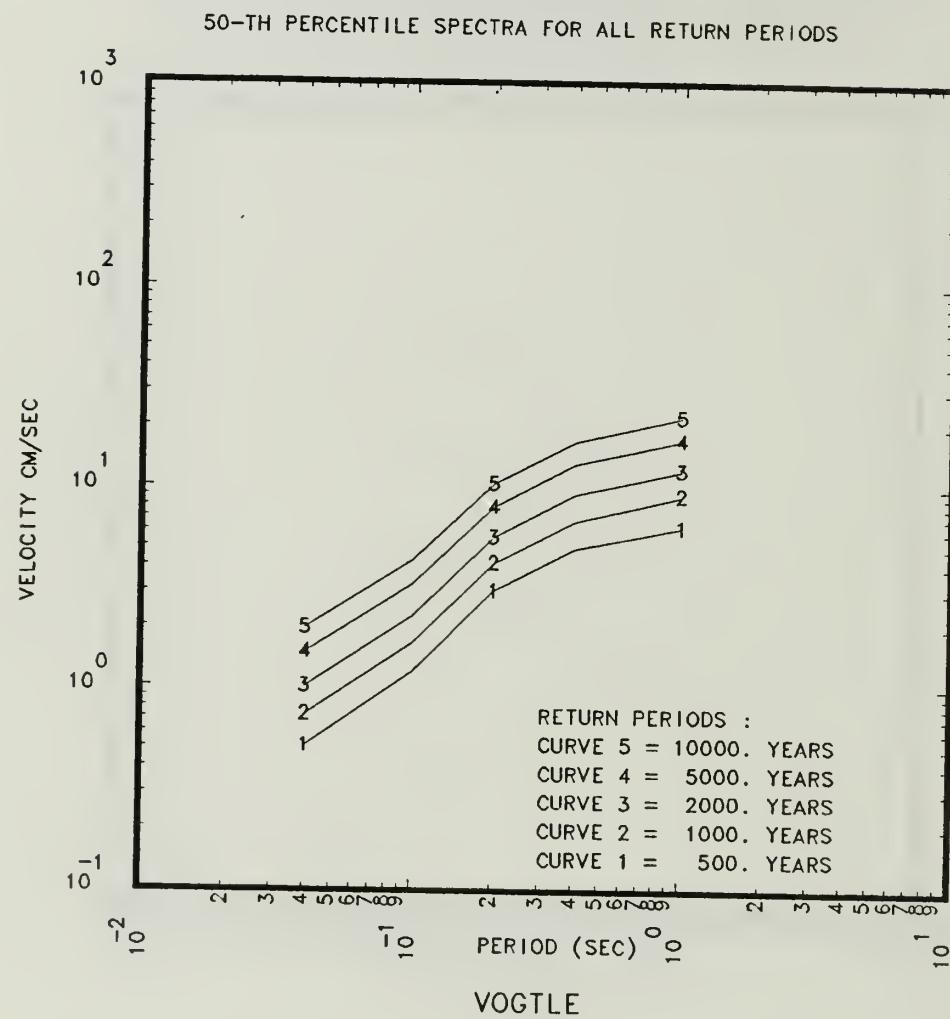


Figure 2.16.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Vogtle site.

2.17 WATTS BAR

Watts Bar is a rock site represented by the symbol "H" on the location map in Fig. 1.1. Table 2.17.1 and Figs. 2.17.1 to 2.17.10 give the basic results for the Watts Bar site.

The AMHC is substantially higher than the 85th percentile CPHC: 30% higher at 0.05g to 2.5 times higher at 1.0g, indicating the presence of outliers in the sample set of hazard curves generated in the Monte Carlo simulations. (See Vol. I, Section 2.3 for more details on the methodology).

The spread of all the S-Expert BEHCs shown in Fig. 2.17.2 is relatively small and indicates a relatively common understanding among the S-Experts for the region around Watts Bar. Table 2.17.1 shows that the centrally located zones play an important role in the total contribution of the hazard at this site. Equally important is the role of the distant New Madrid area which is dominant for some S-Experts, (i.e. S-Experts 1,2,4,5 and 7).

Figure 2.17.4 shows for PGA values above about 0.2g that even if small earthquakes (smaller than magnitude 5.0) were included they would not contribute to the hazard at the Watts Bar rock site. Below that PGA value, the small earthquakes are dominant and at 0.1g, including them would multiply the hazard by a factor equal to 1.75. In addition to the above comments, the typical comments relative to rock sites given in Section 2.1 apply to the Watts Bar site.

TABLE 2.17.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR WATTS BAR

S-EXP. SITE SOIL CATEGORY	HOST ZONE	ROCK	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)	ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT HIGH PGA(0.60G)
1 ZONE 4	ZONE 4 % CONT.: 49.	ZONE 9 32.	ZONE 10 8.	ZONE 11 3.
2 ZONE 27	ZONE ID: ZONE 18 % CONT.: 43.	ZONE 27 35.	ZONE 30 15.	ZONE 20 5.
3 ZONE 5	ZONE ID: ZONE 5 % CONT.: 76.	ZONE 13 11.	ZONE 12 8.	ZONE 11 2.
4 ZONE 13	ZONE ID: ZONE 4 % CONT.: 50.	ZONE 28 31.	ZONE 10 7.	ZONE 9 4.
5 ZONE 11	ZONE ID: ZONE 11 % CONT.: 44.	ZONE 15 36.	ZONE 9 15.	ZONE 14 3.
6 ZONE 12	ZONE ID: ZONE 11 % CONT.: 41.	ZONE 13 19.	ZONE 12 17.	ZONE 17 14.
7 ZONE 7	ZONE ID: ZONE 6 % CONT.: 55.	ZONE 7 39.	ZONE 10 3.	ZONE 5 3.
10 ZONE 28	ZONE ID: ZONE 28 % CONT.: 77.	ZONE 12A 7.	ZONE 26A 2.	ZONE 19 =
11 ZONE 6	ZONE ID: ZONE 6 % CONT.: 77.	ZONE 11 6.	ZONE 8 6.	ZONE 10 6.
12 ZONE 17	ZONE ID: ZONE 19 % CONT.: 60.	ZONE 17 26.	ZONE 15 5.	ZONE 14 2.
13 ZONE 8	ZONE ID: ZONE 8 % CONT.: 73.	ZONE 5 18.	CZ 15 3.	CZ 15 2.
				ZONE 9 8.
				ZONE 1 0.

E.U.S. SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

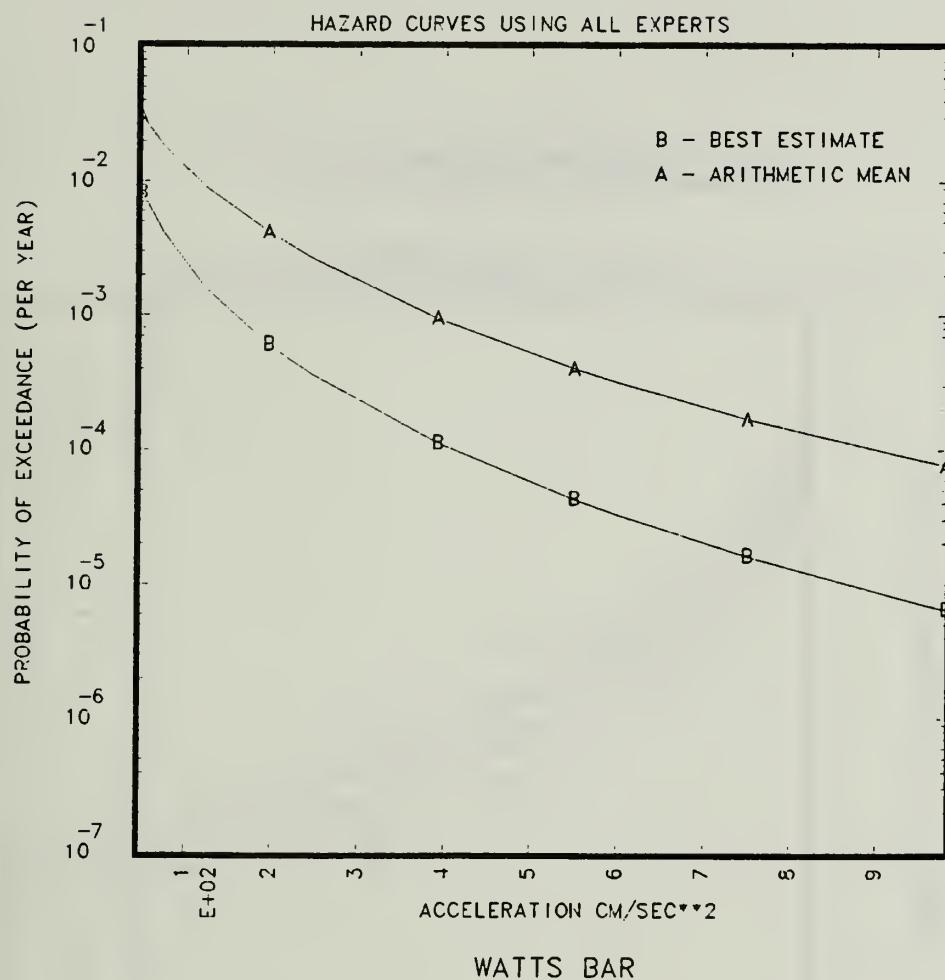


Figure 2.17.1 Comparison of the BEHC and AMHC aggregated over all S and G-Experts for the Watts Bar site.

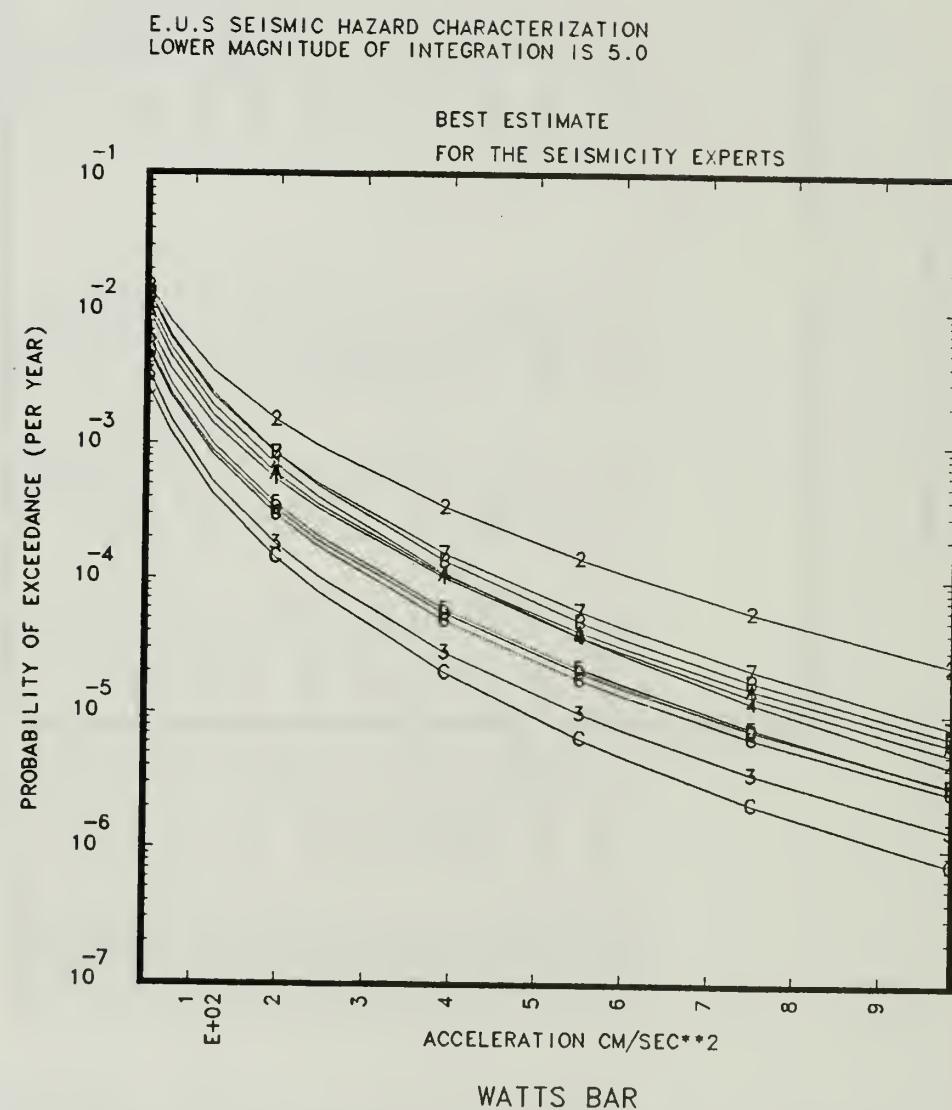


Figure 2.17.2 BEHCs per S-Expert combined over all G-Experts for the Watts Bar site. Plot symbols given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

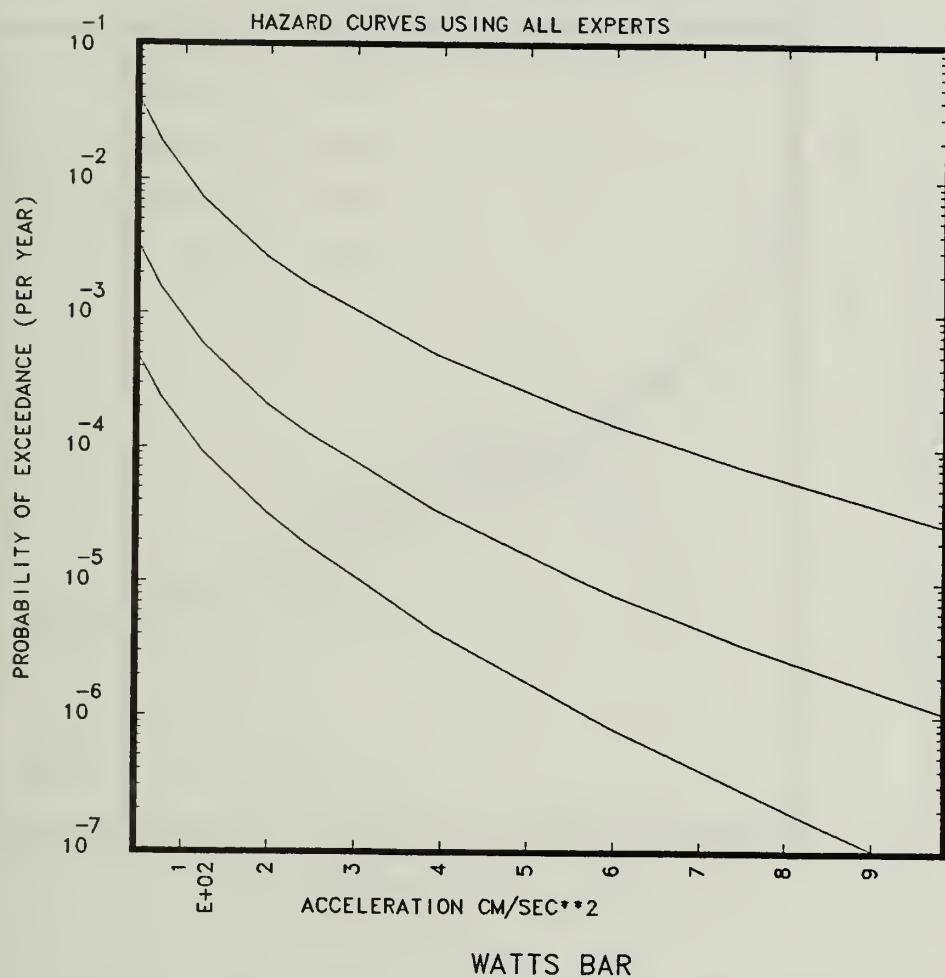


Figure 2.17.3 CPHCs for the 15th, 50th and 85th percentiles based on all S and G-Experts' input for the Watts Bar site.

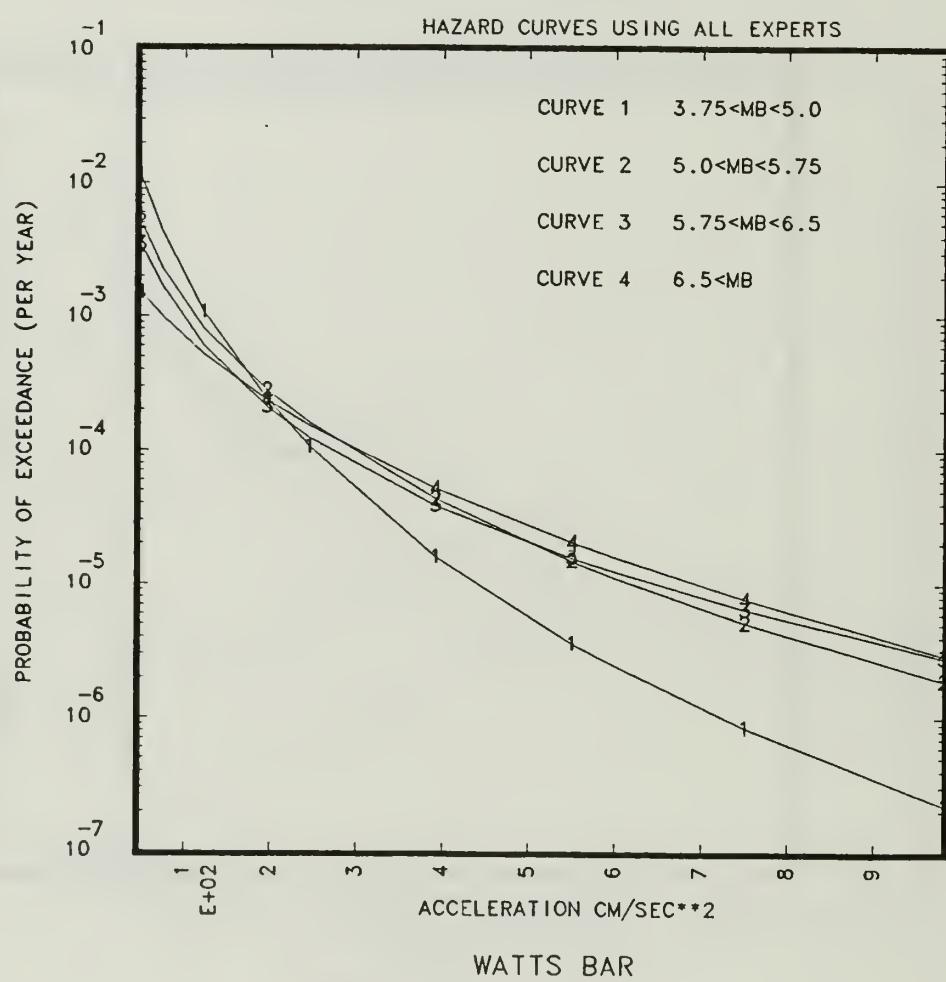


Figure 2.17.4 BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated magnitude range for the Watts Bar site.

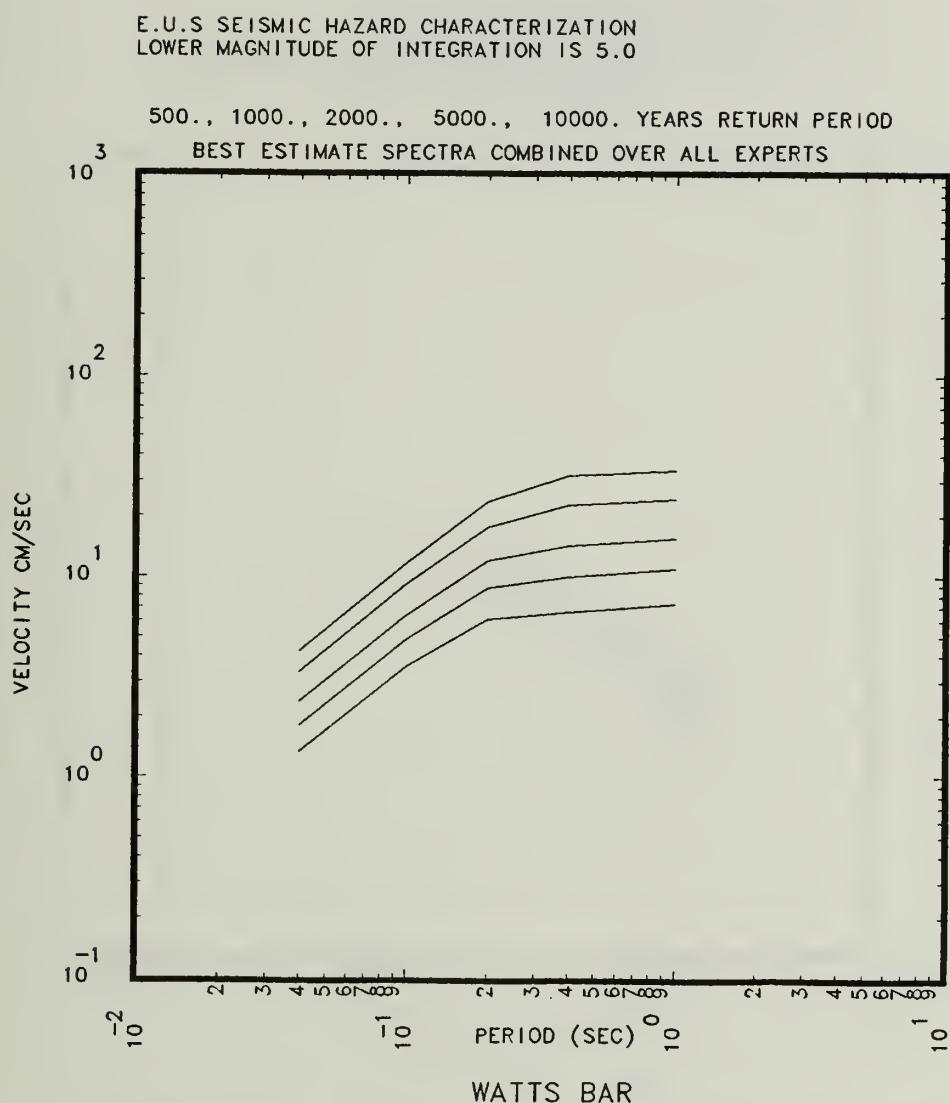


Figure 2.17.5 BEUHS for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Watts Bar site.

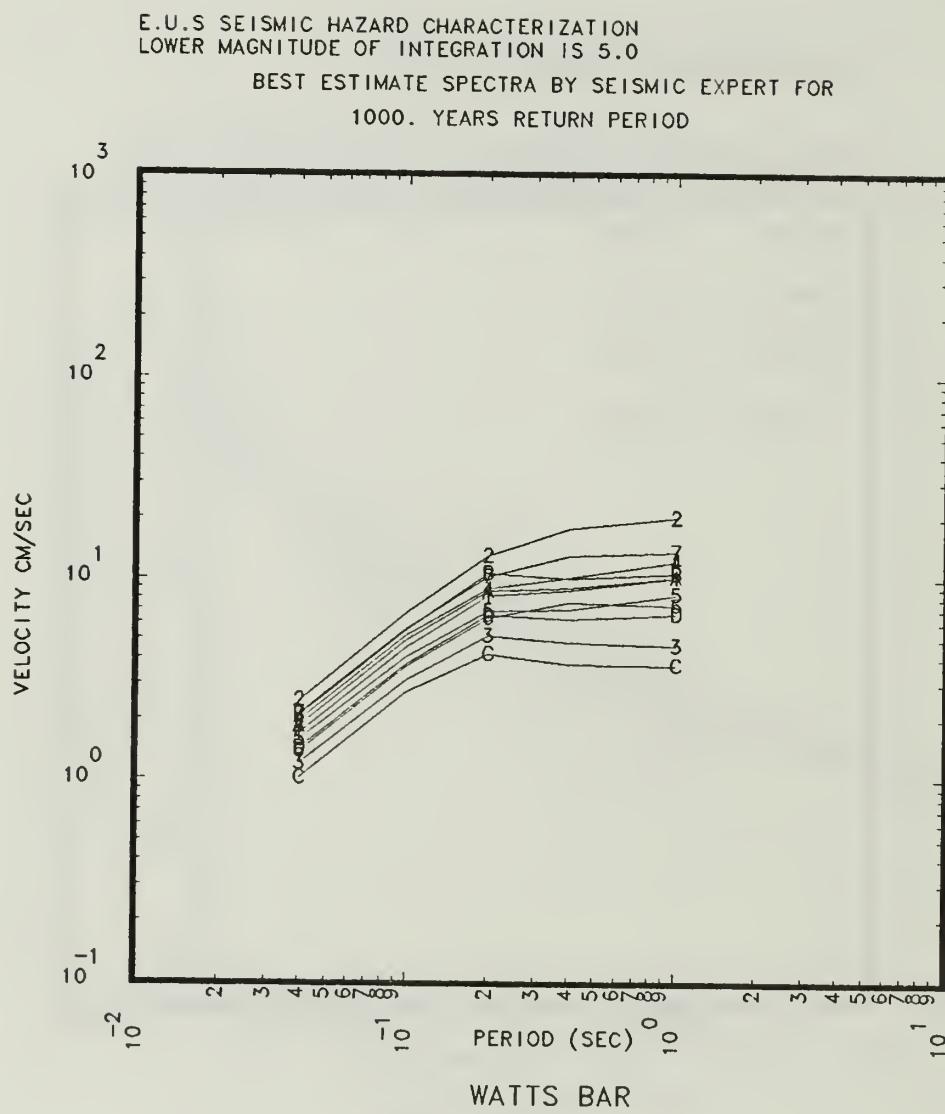


Figure 2.17.6 The 1000 year return period BEUHS per S-Expert aggregated over all G-Experts for the Watts Bar site. Plot symbols are given in Table 2.0.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
500.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

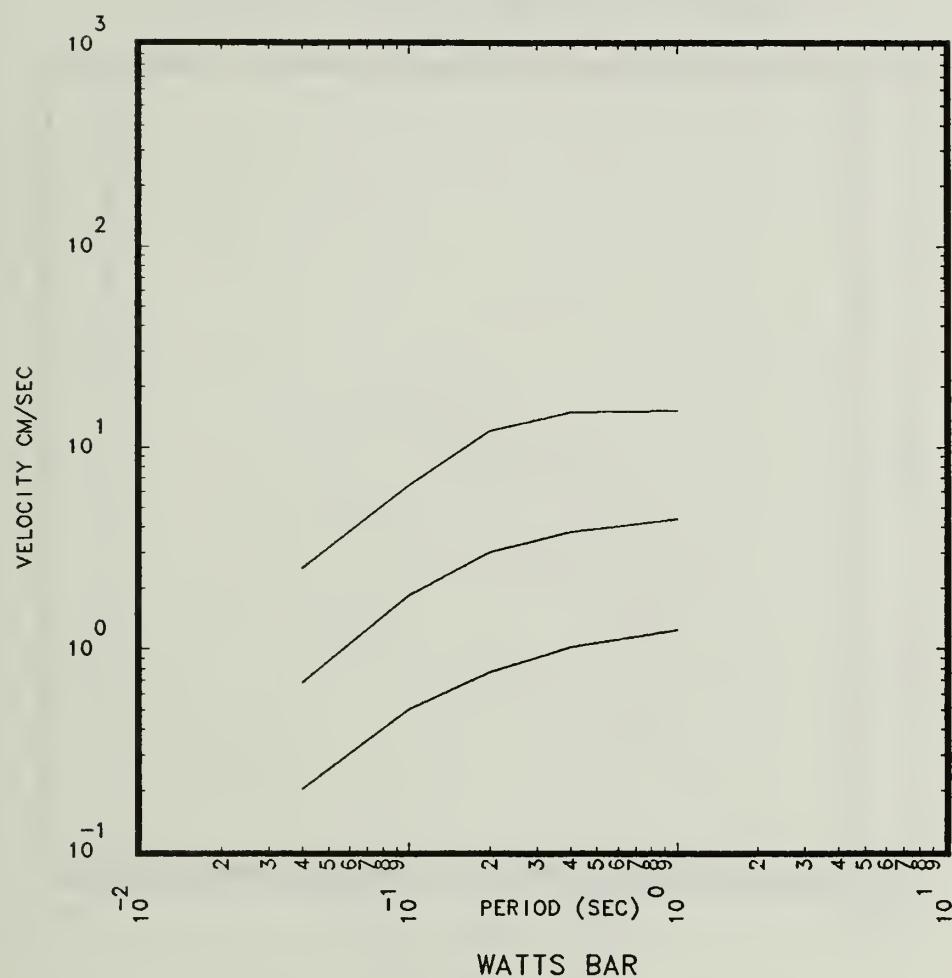


Figure 2.17.7 500 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Watts Bar site.

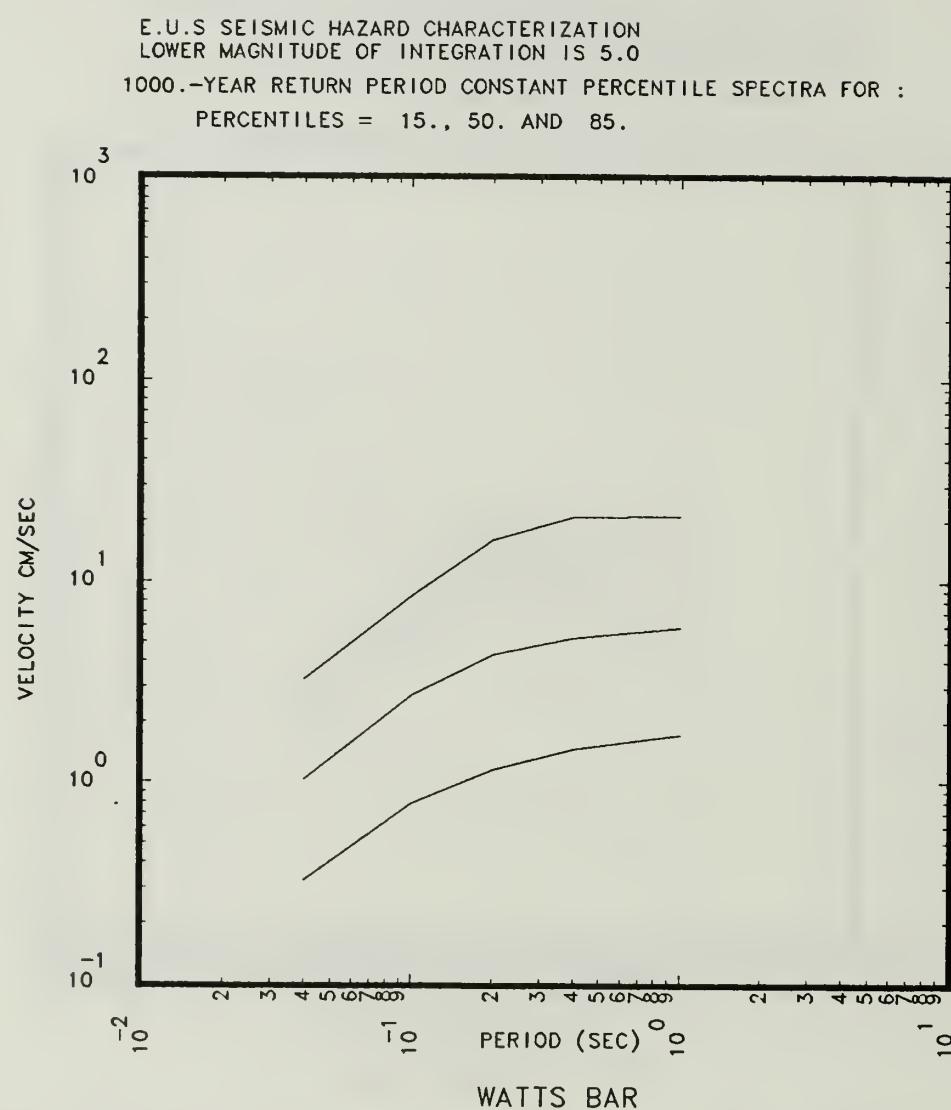


Figure 2.17.8 1000 year return period CPUHS for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Watts Bar site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.

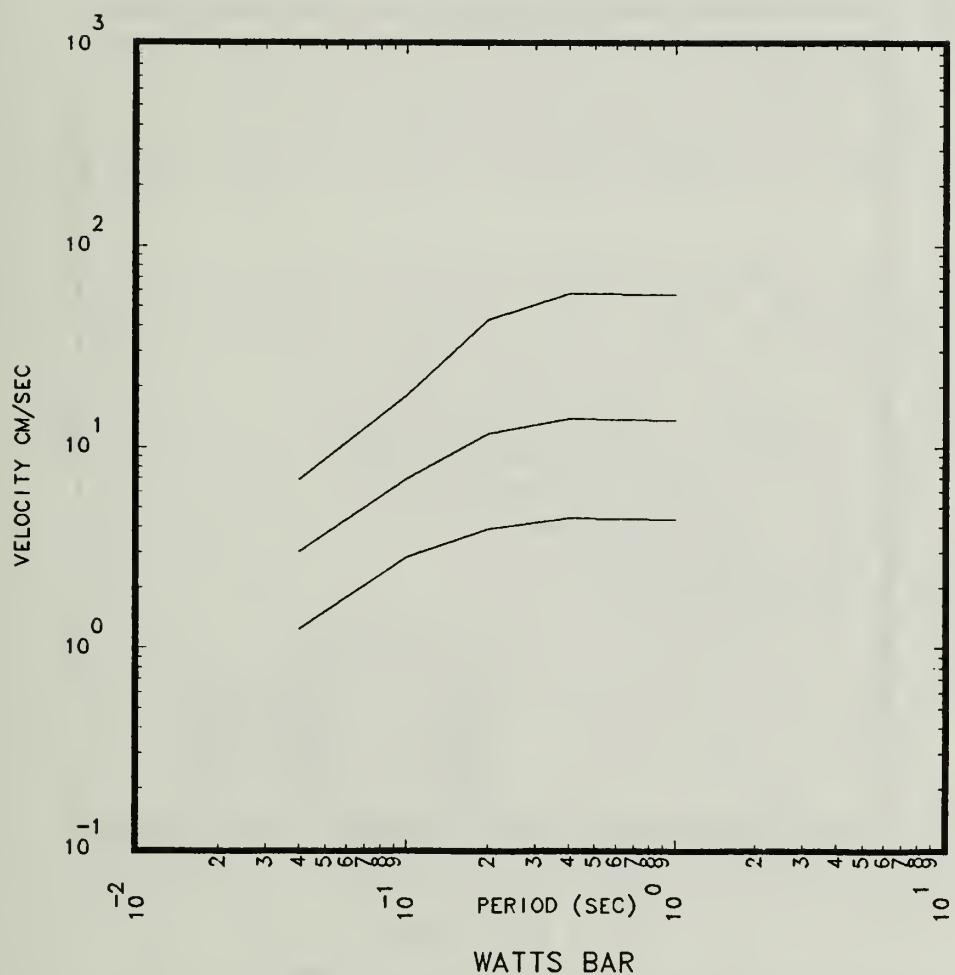


Figure 2.17.9 10000 year return period CPUHS for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Watts Bar site.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

50-TH PERCENTILE SPECTRA FOR ALL RETURN PERIODS

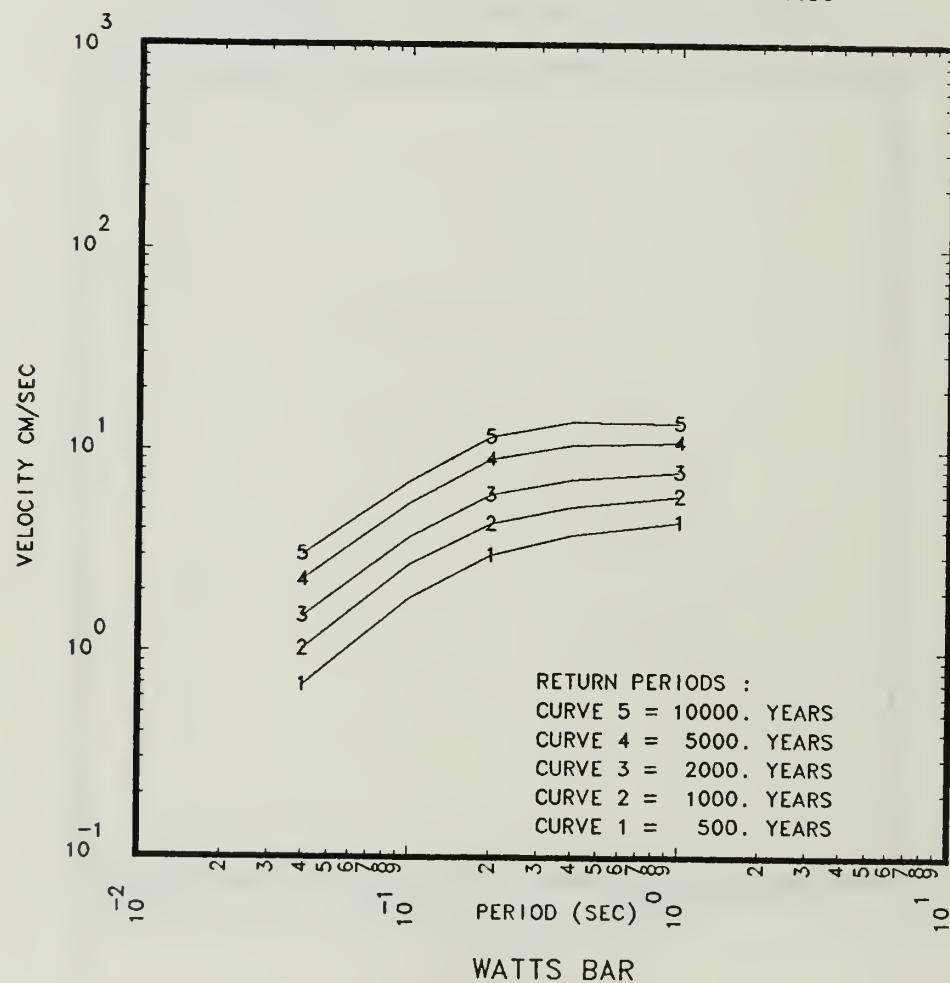


Figure 2.17.10 Comparison of the 50th percentile CPUHS for return periods of 500, 1000, 2000, 5000 and 10000 years for the Watts Bar site.

3. GENERAL DISCUSSION, REGIONAL OBSERVATIONS, AND COMPARISONS BETWEEN SITES

3.1 Uncertainty

Section 2 shows that there are significant differences in the estimated seismic hazard for any site between various experts. In addition, each expert has typically expressed significant uncertainty about his own input which leads to significant uncertainty in the aggregated estimate of the seismic hazard at any site. As explained in Volume 1, we have used a Monte Carlo analysis to develop the distribution function for the seismic hazard. In addition to the uncertainty due to the variety of experts we investigated the variability in the results due to the limitations on the number of simulations in our Monte Carlo uncertainty analysis. For example, to illustrate this uncertainty in Fig. 3.1.1a of Vol. II, which is repeated here as Fig. 3.1.1, we compared the CPHCs for PGA between Hope Creek and Salem sites. Hope Creek and Salem are located side by side. Thus the comparison represents two different sets of simulations for the same site. We see from Fig. 3.1.1 that the median curve is well established and that there are only slight differences between the bounds (as measured by the 15th and 85th percentile curves). There are also only slight differences between the AMHCs for the two different Monte Carlo runs.

A detailed examination of the 2750 hazard curves generated in a Monte Carlo run for a typical site suggests that the distribution of the hazard for a given value of the ground motion parameter (e.g., PGA) is approximately log-normal. However there are some sites such as Bellefonte or Browns Ferry where there is a departure from a log-normal distribution, e.g., as can be seen from Fig. 2.1.3 where we observe that the spread between the median CPHC and the 85th percentile CPHC is larger than between the 15th percentile CPHC and the median CPHC. This phenomenon has been studied in detail in Section 3 of Volume II for the Fitzpatrick site. We repeat here some of Section 3.1 of Volume II for the Fitzpatrick site, but it also applies to other rock sites such as Bellefonte and Browns Ferry where this same phenomenon is observed. In Fig. 3.1.2 we compare the CPHCs for PGA for two different Monte Carlo runs for the Fitzpatrick site. We see from Fig. 3.1.2 that there is a larger difference between the median curves for the two Monte Carlo runs than shown in Fig. 3.1.1. In fact, Fig. 3.1.2 suggests that the 15th and 85th percentile curves are better defined than the median. If reference is made to Figs. 2.1.11 and 2.1.12 it is easy to see what is occurring. That is, as discussed in Section 2.1, G-Expert 5's GM model leads to hazard curves significantly higher than for most other GM modes. Thus, the distribution of hazard curves departs from a log-normal distribution and becomes bimodal so that the 15th and 85th percentile curves are relatively well defined but the 50th percentile curve is less well defined. However, even in this worst case, the differences between two Monte Carlo runs are not really large. It varies from practically no difference at low PGA values, say below 0.2g, to differences in the range of 10 percent at most in the probability of exceedance at PGA values above 0.6g. Nevertheless, these differences between two Monte Carlo runs must be kept in mind when making comparisons between nearby sites.

3.2 Sensitivity to Region Choice

In Volume I we indicated that we divided the EUS into four regions (northeast, southeast, northcentral, and southcentral) in order to give our G-Experts a chance to introduce regional corrections for attenuation and to give our S-Experts a chance to account for varying expertise for different regions. The boundaries between these regions are very approximate, thus as indicated in Section 2, all Batch 2 sites were considered to be located in region 2. However, several sites could be also considered to be in either region 1,2 or 3. The major impact of region placement is due to G-Expert 2's input. As can be seen from Tables 3.5 and 6 of Volume 1, only G-Expert 2 introduced a regional variation in his GM models. In region 1 he selected a different BE model than for regions 2,3 and 4. Thus the BEHC and BEUHS change depending upon whether the site is considered to be Region 1 or the other regions. In addition, it depends on whether it is a rock or a soil site with the effect being larger for a soil site than for a rock site. In Section 3.2 of Vol. II we examined the significance of the choice of region on the hazard. For ease of reference, it is repeated in the following paragraphs.

In Fig. 3.2.1 we show a comparison between the PGA hazard curves for the case when the Hope Creek site is considered to be located in region 1 and the case when it is considered to be located in region 2. We see from Fig. 3.2.1 that there is a noticeable difference between the BEHCs and the AMHCs for the two cases. There is some difference between the CPUHS as shown in Fig. 3.2.2 where 10,000 year return period CPUHS are plotted for the two cases.

The sensitivity to location placement is even less for rock sites as shown in Figs. 3.2.3 and 3.2.4. In Fig. 3.2.3 we show the BEHCs and AMHCs for the case when the Limerick site is considered to be located in region 1 and the case when it is considered to be located in region 2. It can be seen from Fig. 3.2.3 that the difference between the two cases is less than shown in Fig. 3.2.1. The difference between the CPHCs and the CPUHS for the two cases for Limerick site is small.

Overall we see that, for the sites located near the border between what we have defined as region 2 (southeast) and region 1 (northeast) the actual assignment of the region makes very little or no differences on the CPHCs and CPUHS. It makes some difference, in the order of 10 percent maximum at low PGA values and a maximum of 40 to 50 percent at high PGA values, on the probability of exceedance, on the BEHCs and AMHCs, particularly for soil sites. But given the overall uncertainty, as measured by the spread between the 15th and 85th percentile CPHCs the sensitivity due to region assignment is negligible.

3.3 Factors Influencing Zonal Contribution to the Hazard

A number of factors influence how significantly a given seismic source zone contributes to the hazard at any given site for any given S-Expert. Several factors are obvious and a few may not be so obvious. The main factors that influence zonal contribution to the hazard can be separated into three groups:

1. Attributes of the seismic zone in question:

- o Distance from the zone to the site.
- o The rate of activity in the zone.
- o The b-value used for the zone.
- o The upper magnitude cut off for the zone.
- o The probability of existence of the zone.
- o The size of the zone.

2. Attributes of the ground motion model:

- o The rate at which the peak ground motion attenuates with distance.
- o The site's soil category.

3. Attributes of the hazard analysis methodology:

- o Uncertainty analysis performed.
- o Lower bound of integration for magnitude.

Let us start our discussion on the significance of the above factors in the inverse order, i.e. start with set listed under (3) above. We made the point in Section 2 that the Tables 2.SN.1 were based only on BE input and thus did not in all cases capture the true contribution of a given zone to the hazard for a specific site. The contribution of a given zone listed in Tables 2.SN.1 might be too high if a zone's probability of existence is relatively low and it is not listed if the probability of existence is less than 0.5 because in this latter case the zone could not belong to the BE map.

In our analysis the modeling uncertainty in the site correction is accounted for by allowing for several different types of corrections to be performed (see Section 3.7 Vol. I). The type of correction performed also can impact on how the ground motion model (or models) affect the seismic hazard and how correction for the site's soil category is made. This will be discussed later. Other elements of the uncertainty analysis such as the variation in zone boundary shape, variation in rate of activity etc. are less important and generally do not play a major role in determining the zonal contribution to the hazard.

The lower bound for magnitude used in the analysis is of some significance at the low g-value end. This is illustrated in Figs. 3.3.1a and b. In Fig. 3.3.1a we show the contribution to the BEHC for PGA from all the earthquakes in four distance rings about a site in the EUS when the lower bound of integration for magnitude is 5.0. In Fig. 3.3.1b we show the same thing except the lower bound of integration has been reduced to 3.75. We see by comparing Figs. 3.3.1a to 3.3.1b that, when the lower bound of integration is lowered to 3.75, the earthquakes in the region within 15 km of the site contribute significantly more to the hazard at lower PGA levels and there is also a marked increase in the contribution from earthquakes within 15 to 50 km

from the site. At high PGA levels there is little effect of changing the lower bound of integration. Of course, if the lower bound was yet even higher than 5, the effect would be more significant even to much higher PGA levels.

Let us now address group (2) - attributes of the GM model. First, let us note that if there were no modeling uncertainty, (i.e., if we knew the correct form for the GM model) then the attributes of the GM model would not influence the zonal contribution. If no uncertainty analysis is being performed (e.g. Algermissen et. al. (1982)) then it is the same as saying we know the correct form for the GM model. In our analysis we have included uncertainty about GM modeling in three ways:

- (1) We used multiple GM models.
- (2) We introduced multiple ways to correct for the effect that the site's category has on the estimated ground motion.
- (3) We varied the random uncertainty associated with each GM model.

All three of the above are important.

In Section 2.1 we have already made the point that one of the BE GM models has a significantly lower attenuation rate than the other BE GM models. This can make a significant difference as is illustrated in Figs. 3.3.2a and b. In Fig. 3.3.2a we show the contribution to the BEHC for PGA from the earthquakes located in four distance ranges when all the BE GM models are used for a rock site in the EUS. In Fig. 3.3.2b we show the same thing as in Fig. 3.3.2a except only G-Experts 1-4's BE GM models are used. That is, we have eliminated the GM model with low attenuation. It is evident from comparing Figs. 3.3.2a and b that the uncertainty about the correct GM model is very significant and can have an important impact on determining which zones contribute to the hazard at a site.

Our uncertainty about how to correct the GM for the soil conditions at a site impacts the estimate of the ground motion differently for various ground motion models. This is illustrated in Figs. 3.3.3a and 3.3.3b. In Fig. 3.3.3a we show the contribution to the BEHC for PGA for four distance ranges for a rock site. In Fig. 3.3.3.b we show the contribution to the BEHC for PGA for the same four distance ranges for a soil site. The soil site was placed in the Till-2 soil category. The two sites are located relatively close to each other thus we would expect little difference in the seismic hazard between these two sites. We see however from comparing Figs. 3.3.3a and 3.3.3b that there is a considerable difference between the two sites in the distance ranges which contribute most to the BEHCs for PGA.

It should be noted that the differences between the distribution of which distance bands contribute most to the BEHCs for PGA for rock sites as compared to soil sites is typically the difference between Figs. 3.3.3a and 3.3.3b. However, there is some variation between the various rock sites and the various soil sites depending upon their location.

The group (1) - attributes of the zone in question-are relatively easy to understand and are generally the factors which we expect to control a given zone's contribution to the seismic hazard at a site. In Section 2 we gave examples of how the group (1) factors influence this contribution.

From the above discussion we can conclude that care must be taken when using the information given in Tables 2.1.1 to 2.17.1. The information is useful, but, as indicated, it can give a distorted picture of which zones are most significant. Unfortunately, in complex cases the only way to get an undistorted understanding is to perform a detailed sensitivity analysis. However, one can gain a relatively good understanding of what is important by carefully examining the data given in Tables 2.SN.1, the zonation maps for each S-Expert, the seismicity data for each S-Expert given in Appendix B and keeping in mind the sensitivities discussed in this section. One could also do a magnitude and distance sensitivity analysis of the CPHCs to gain a better understanding.

3.4 Comparisons of the Seismic Hazard Between Sites

In this project the seismic hazard has been defined as the annual probability of exceedance of a given level of peak ground motion. Thus, strictly speaking, we only need to compare hazard curves between sites to reach a conclusion about the relative hazard at various sites. However, large uncertainties exist in the estimates of the peak ground motion and in the conversion of a given level of peak ground motion into a risk number. This suggests that we need to also introduce some subjective judgment into the process of assessment of the relative hazard between sites. In this section we compare the computed seismic hazard and examine some important elements that should be factored into assessment of the relative hazard between the sites located in region 2.

When comparing the hazard between two sites, the most important factors to be considered are the potential differences in soil categories between the two adjacent sites. For example, in Fig. 3.4.1 we compare the median CPHC for two sites. We would generally expect that there would be little difference between the seismic hazard for these two sites. However Fig. 3.4.1 shows that there is considerable difference. One is a rock site, the other is a soil site (Category Till-2). A complete discussion on the local site effects on ground motion is given in Volume VI, and Fig. 3.4.1 shows that it is very significant.

In addition to soil category, one must consider which estimator of the hazard should be used because in some cases different estimators would lead to different conclusions about the relative hazard between two sites. For example, the median CPHC is significantly lower at the Browns Ferry site as compared to Bellefonte; however, the AMHC and BEHC are higher at Browns Ferry than at Bellefonte. Other examples are given later.

Most of the comparisons made in the rest of this section are relative to the median hazard curve because it proved to be the most stable of the estimators. Generally, the spread between the 15th and 85th CPHCs gives an idea of uncertainty at a given site. However, this spread may not fully capture the uncertainty because of departures from a log normal distribution. In these cases there will generally be a larger spread between the 50th and 85th CPHCs than the 15th and 50th CPHCs; e.g., see Fig. 2.2.3.

As one would expect, the hazard is not uniform over region 2. In Fig. 3.4.2 we compare the median CPHCs for five rock sites spread across region 2. It can be seen from Fig. 3.4.2 that there is a wide variation in the seismic hazard in the region.

It is instructive to compare the contribution to the BEHCs for various magnitude and distance ranges between the five sites plotted in Fig. 3.4.2. The contribution to BEHCs from earthquakes in 4 magnitudes ranges are given in Section 2 (Figs. 2.6.4, 2.9.4, 2.10.4, 2.13.4 and 2.17.4) for the Farley, North Anna, Oconee, Shearon Harris and Watts Bar sites. Comparing these figures we see some differences between the sites. For example, larger magnitude earthquakes contribute less to the hazard at the North Anna site than at the other sites, and conversely, large magnitude earthquakes are more significant at the Farley site than at the other sites.

Figures 3.4.3, 3.4.4 and 3.4.5 give the contribution to the BEHC for the North Anna, Shearon Harris and the Watts Bar sites from four distance ranges, Fig. 2.10.11 for the Oconee site. There are some interesting differences between the relative contributions to the BEHC from each of the four distance ranges for several of the sites that are compared in Fig. 3.4.2. For example, we see at the Shearon Harris site that most of the contribution to the BEHC for PGA is from earthquakes farther than 150 km away. Distant earthquakes are also more important at the Oconee site than at the North Anna site. Distant earthquakes are least important at the North Anna site. This latter fact also goes with the fact that large earthquakes are least important at the North Anna site.

In Fig. 3.4.6 we compare the median CPHCs for the Calvert Cliffs, Hatch, Robinson, Surry, and Vogtle (deep soil) sites.

The spectra curves show much of the same differences between sites as the PGA curves. However, because the spectral ordinates are plotted on a log scale whereas the PGA is plotted on linear scale, the differences between sites are more noticeable for PGA comparisons than for spectral comparisons. Nevertheless some interesting differences can be observed by making spectral comparisons. For example, in Fig. 3.4.7 we compare the 10,000 year return period median CPUHS for the Oconee site and North Anna site for which smaller

nearby earthquakes are more significant than at the Oconee site as reflected by the shapes of the CPUHS. We see from Fig. 3.4.7 that the CPUHS for the North Anna site bends downward at higher periods (beyond 0.3 seconds period) faster than for the Oconee site.

Figure 3.4.8 shows a comparison of four of the rock sites response spectra for 10,000 years return period. The four sites, Bellefonte, Browns Ferry, Sequoyah and Watts Bar have the additional characteristic of being all subject to large earthquakes which dominate the hazard at these sites.

The difference in shapes between the relatively nearby sites of Browns Ferry and Bellefonte can be explained by comparing Figs. 2.1.4 to 2.2.4. We see from this comparison that more of the hazard at the Browns Ferry site is from large (more distant) earthquakes than at the Bellefonte site. Thus there is more long period motion at the Browns Ferry site and less short period motion than at the Bellefonte site. Comparison of Table 2.1.1 to Table 2.2.1 also confirms that local zones are more important at the Bellefonte site than at the Browns Ferry site. At the Browns Ferry site the New Madrid zones are more important than at the Bellefonte site.

In Fig. 3.4.9 we compare the median CPHC for all the sites listed in Table 1.1. The variation between sites includes all of the factors we have discussed such as site category and differences in zonation between sites. We see from Fig. 3.4.9 that the Watts Bar site has the highest median hazard at levels above 0.3g and that the Sequoyah site has the highest median hazard below 0.3g. It is interesting to note that at low g values the median hazard at the Brunswick site is significantly lower than at either the Watts Bar, Sequoyah or Oconee sites, yet at very high g levels the median hazard at the Brunswick site is as high as the hazard at Watts Bar and higher than at either the Sequoyah or Oconee sites.

It should be kept in mind that much of the above discussion was based on comparisons between median estimators of the seismic hazard at various sites. As we have pointed out earlier other estimators of the hazard might lead to different conclusions. To illustrate this point refer to Fig. 3.4.10 which shows several estimates of the probability of exceedance of 0.2g for each of the 17 sites of batch 2.

According to Figure 3.4.10, the four sites with the highest probability of exceedance of 0.2g are site numbers 1, 2, 12 and 17, when the estimator is the arithmetic mean (symbol A on Fig. 3.4.10). When the median is the estimator (symbol M in Fig. 3.4.10) of interest, the four sites are 1, 10, 12 and 17. On the other hand, using the 85th percentile (symbol * in Fig. 3.4.10), the four sites are sites 1, 2, 12 and 17, and using the best estimate (symbol B in Fig. 3.4.10) gives sites 1, 2, 14 and 17.

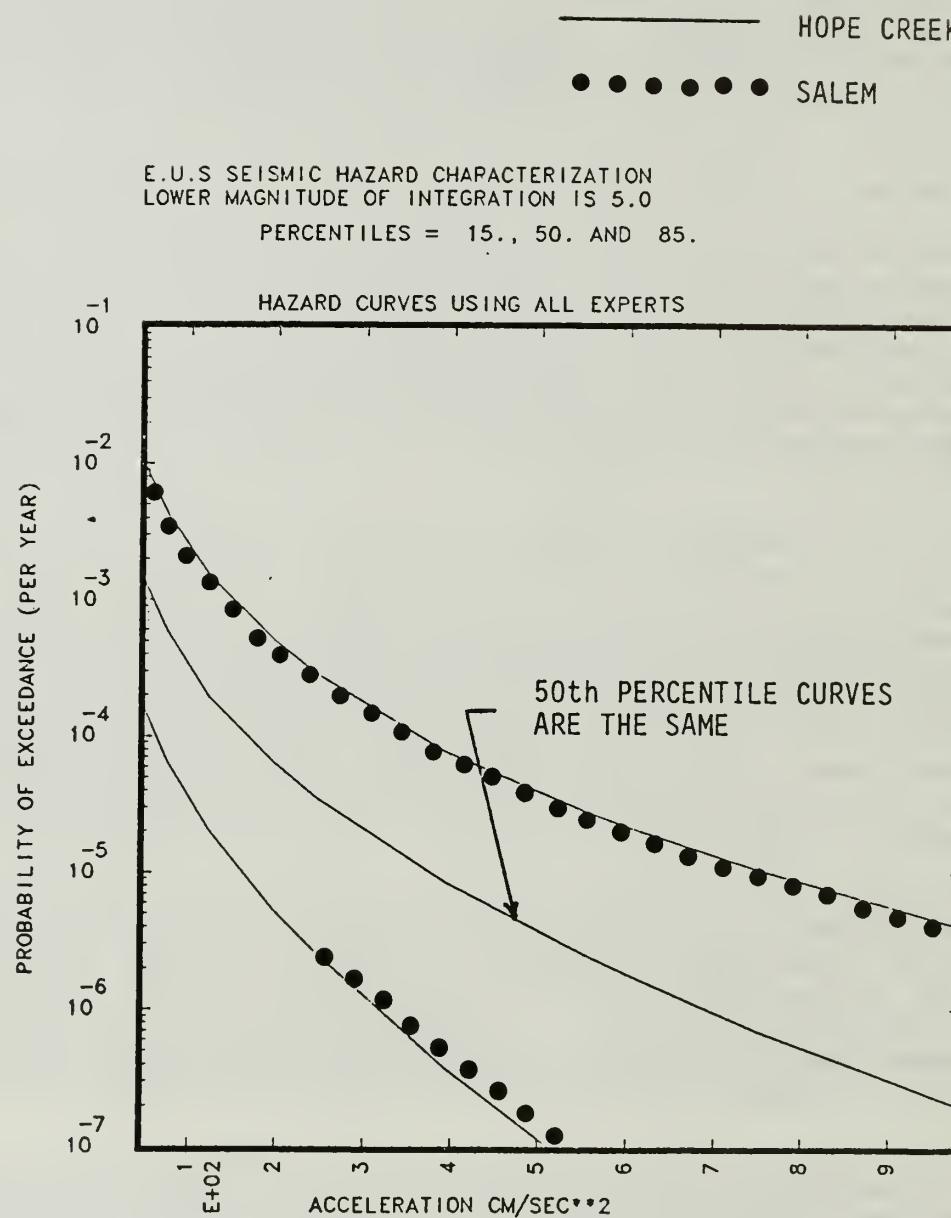


Figure 3.1.1 Comparison of the 15th, 50th and 85th percentile CPHCs for PGA between the Hope Creek and Salem sites. Repeated from Vol. II.

— RUN 1
○ ○ ○ ○ ○ ○ RUN 2

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.

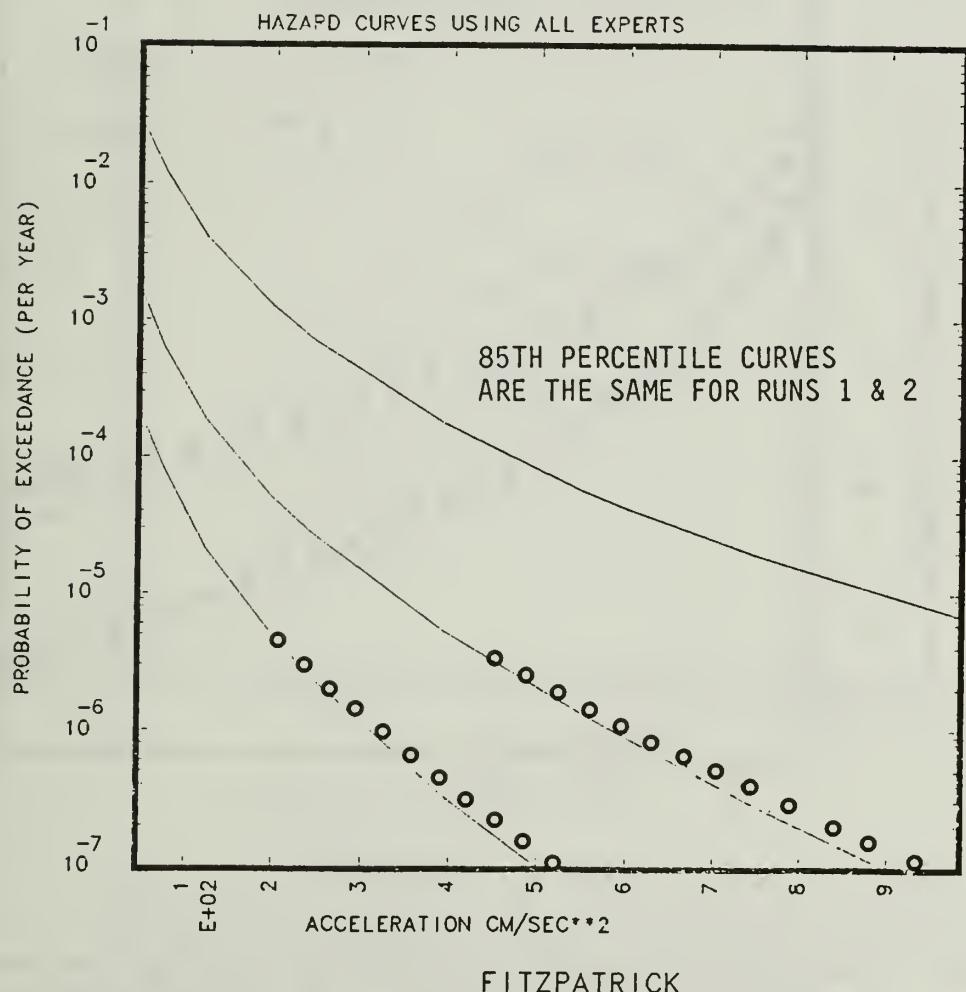


Figure 3.1.2 Comparison of the 15th, 50th and 85th percentile CPHCs for PGA between two different Monte Carlo runs for the Fitzpatrick site. Repeated from Vol. II.

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

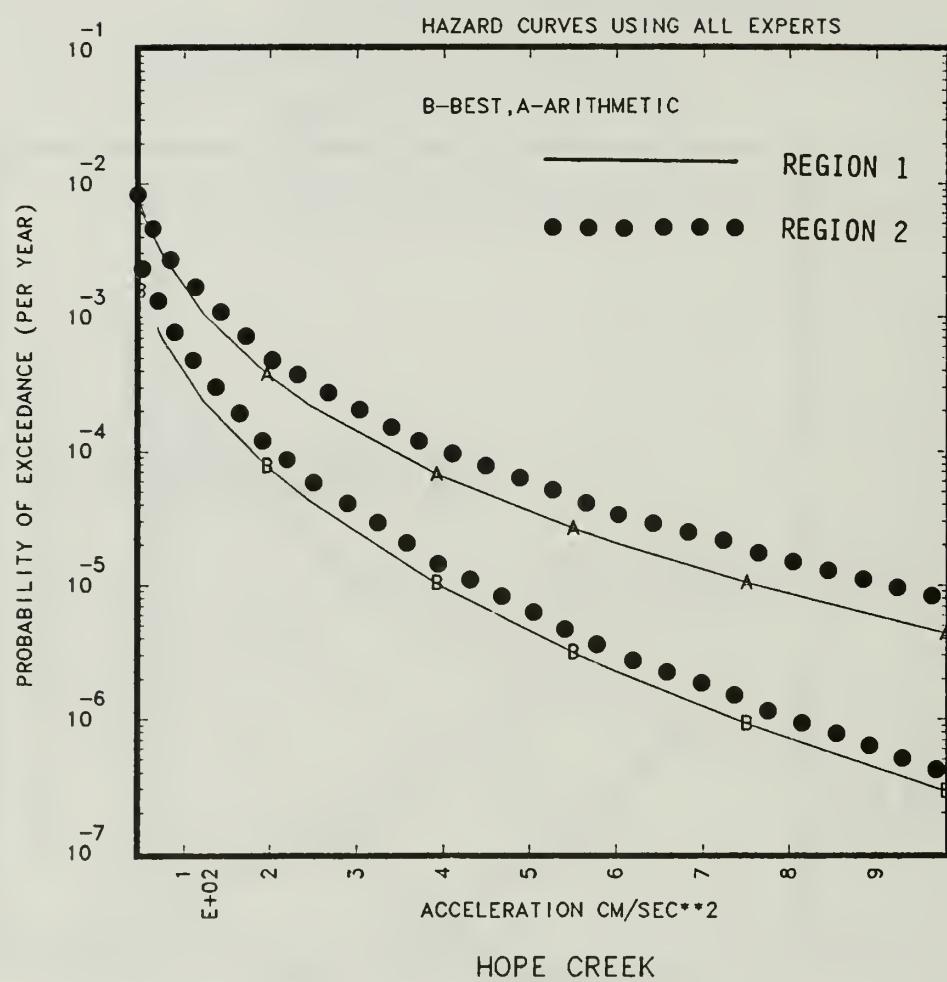


Figure 3.2.1 Comparison of the BEHCs and AMHCs between the case when the Hope Creek site is considered to be located in region 1 and the case when it is considered to be located in region 2.

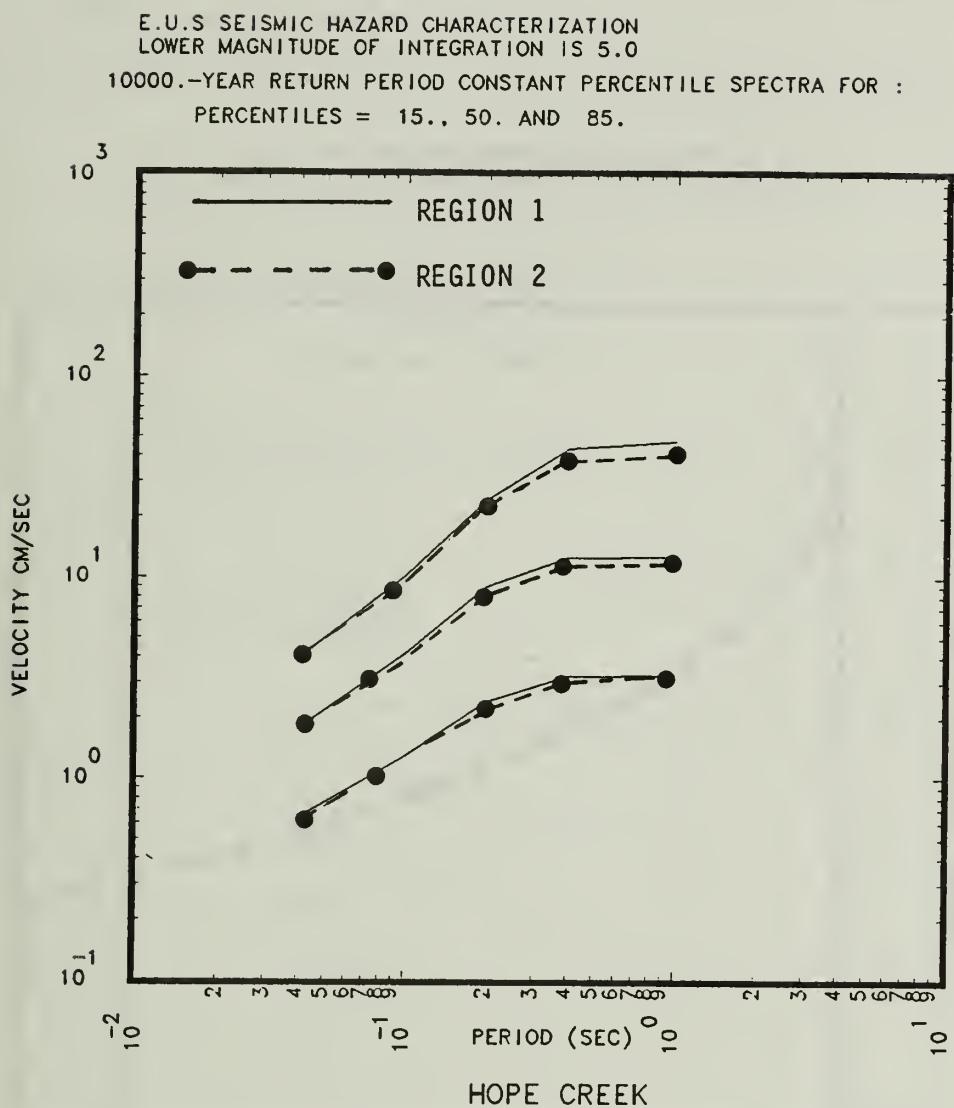


Figure 3.2.2 Comparison of the 10,000 year return period 15th, 50th and 85th percentile CPUHS for the Hope Creek site between the case when the Hope Creek site is considered to be located in region 1 and the case when it is considered to be located in region 2.

● ● ● ● ● ● ● REGION 1
 ━━━━━━ REGION 2

E.U.S SEISMIC HAZARD CHARACTERIZATION
LOWER MAGNITUDE OF INTEGRATION IS 5.0

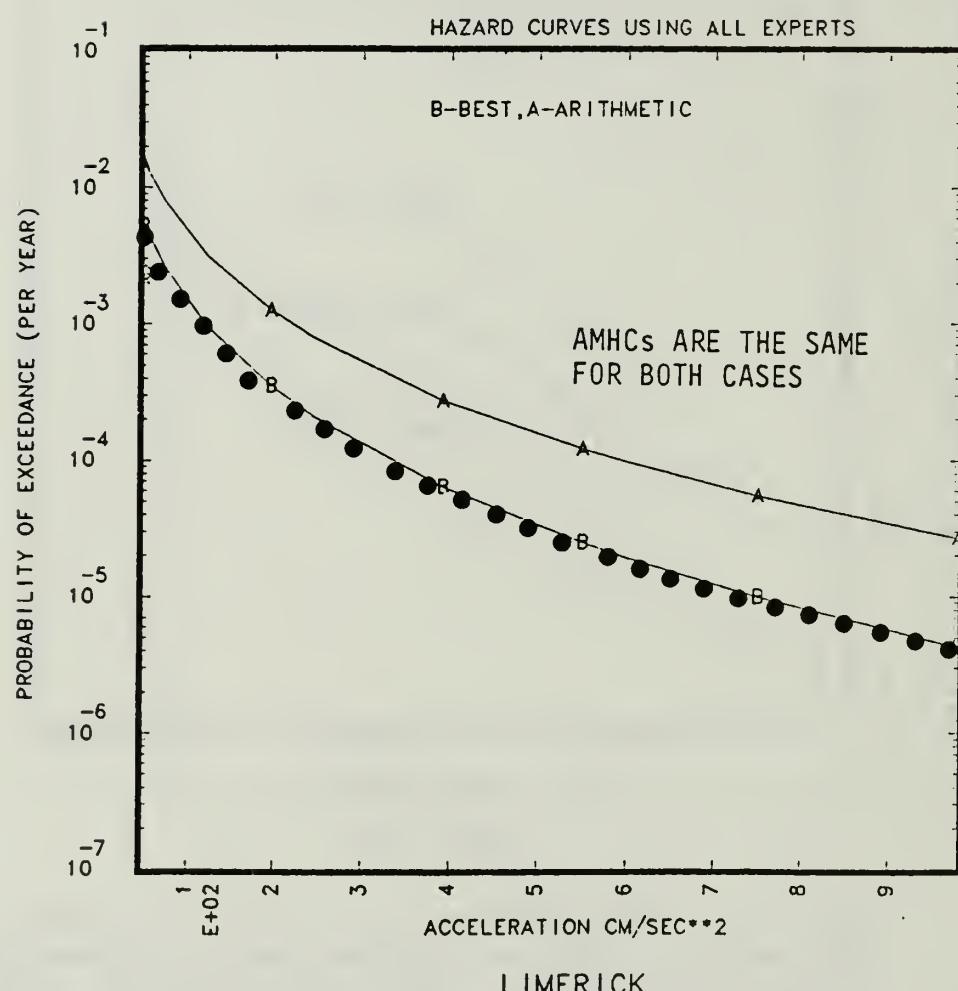


Figure 3.2.3 Comparison of the BEHCs and AMHCs for the Limerick site between the case when the Limerick site is considered to be located in region 1 and the case when it is considered to be located in region 2.

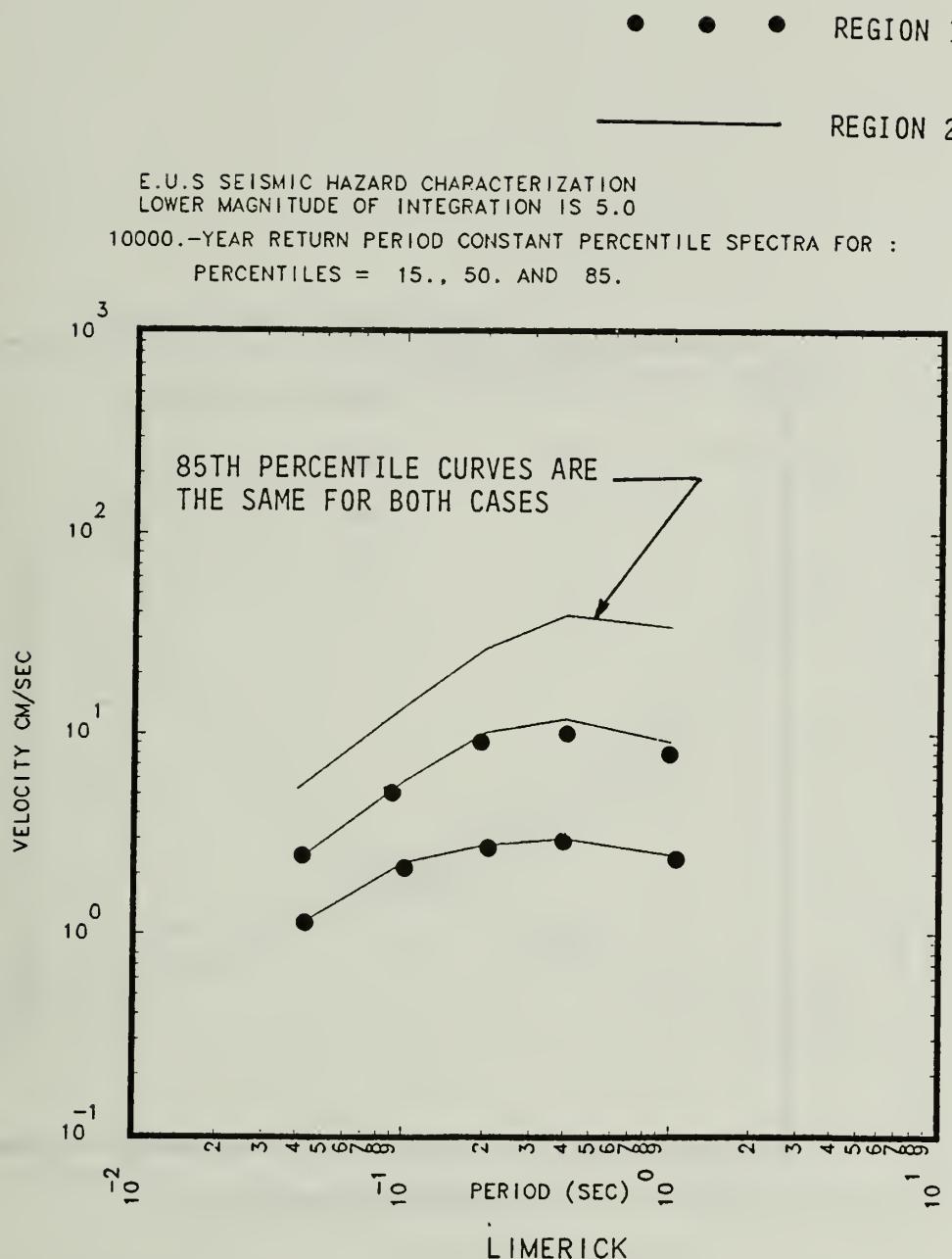


Figure 3.2.4

Comparison of the 10,000 year return period 15th, 50th and 85th percentile CPUHS for the Limerick site between the case when the Limerick site is considered to be located in region 1 and the case when it is considered to be located in region 2.

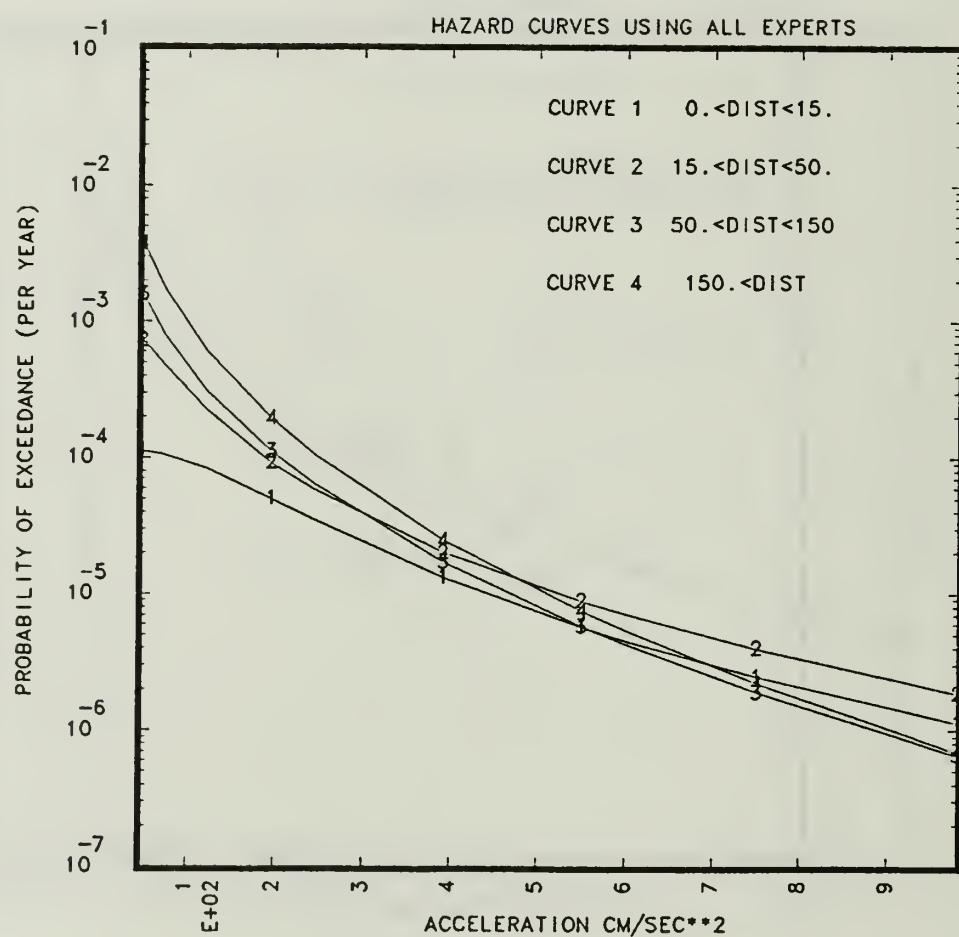


Figure 3.3.1a BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated distance ranges for a site in the EUS when the lower bound of integration for magnitude is 5.0.

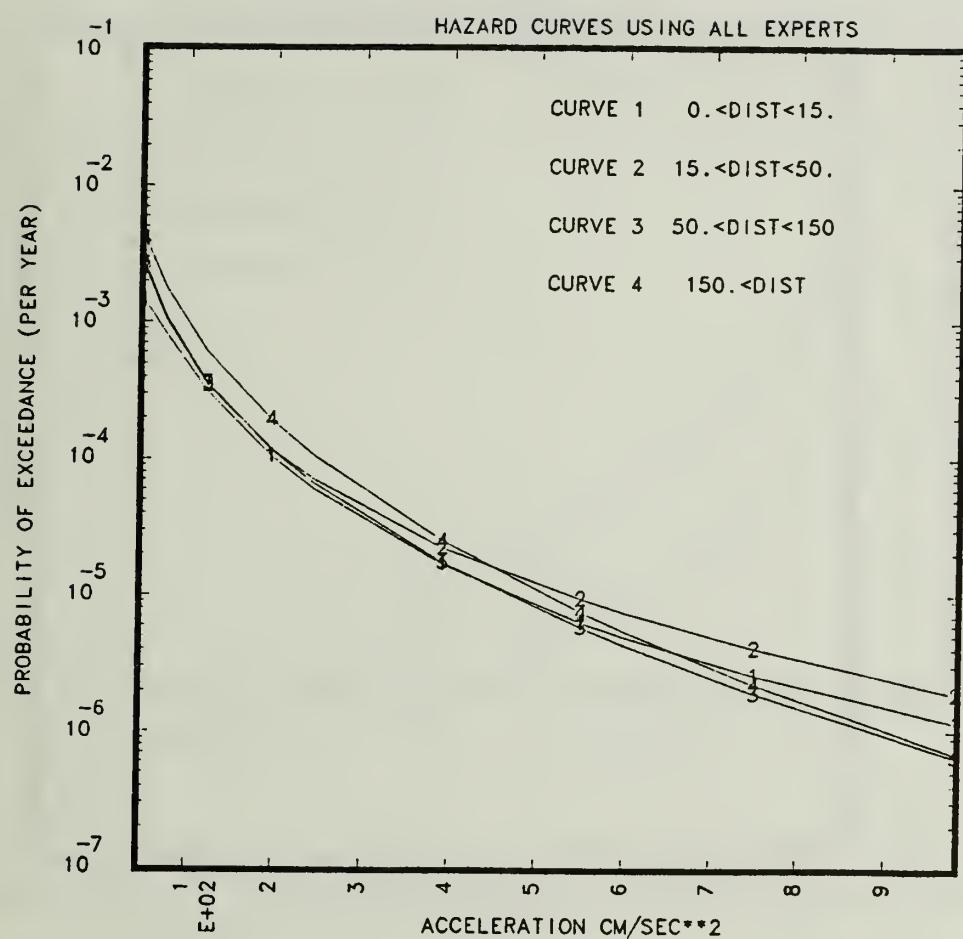


Figure 3.3.1b BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated distance ranges for the site considered in Fig. 3.3.1a when the lower bound of integration is 3.75.

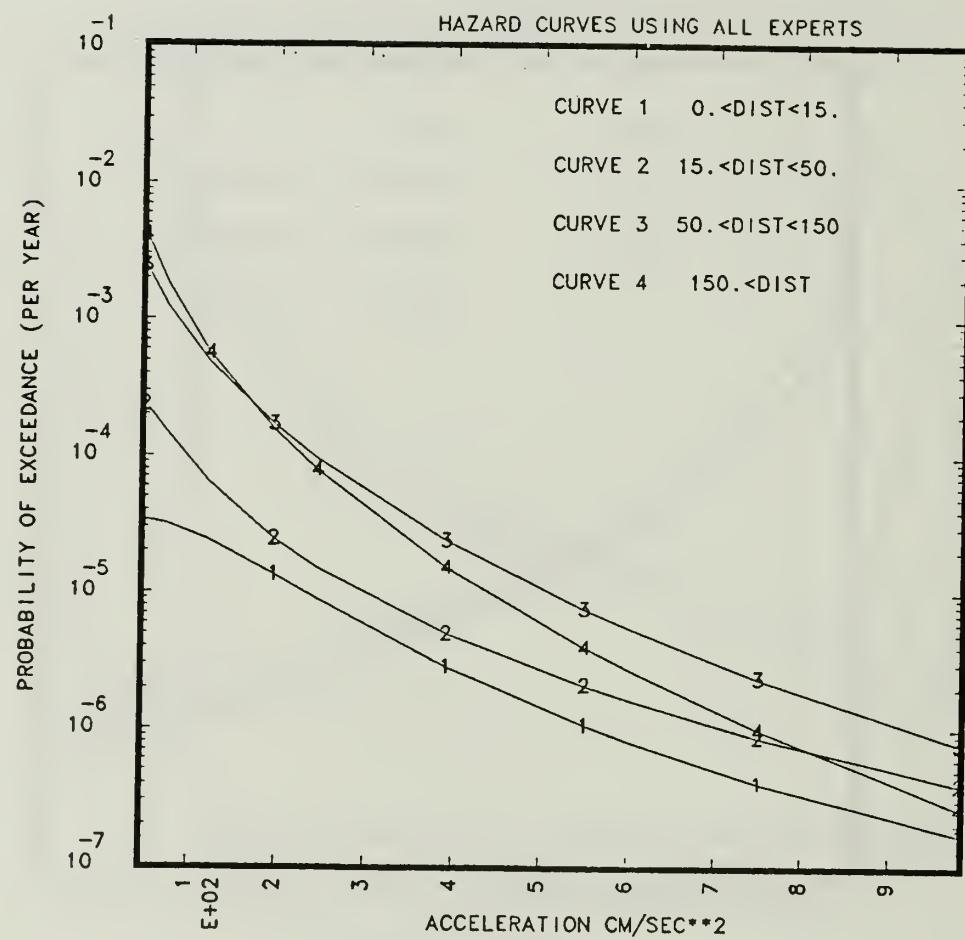


Figure 3.3.2a BEHCs which include only the contribution to the PGA hazard from earthquakes within the indicated distance ranges for a rock site of the EUS.

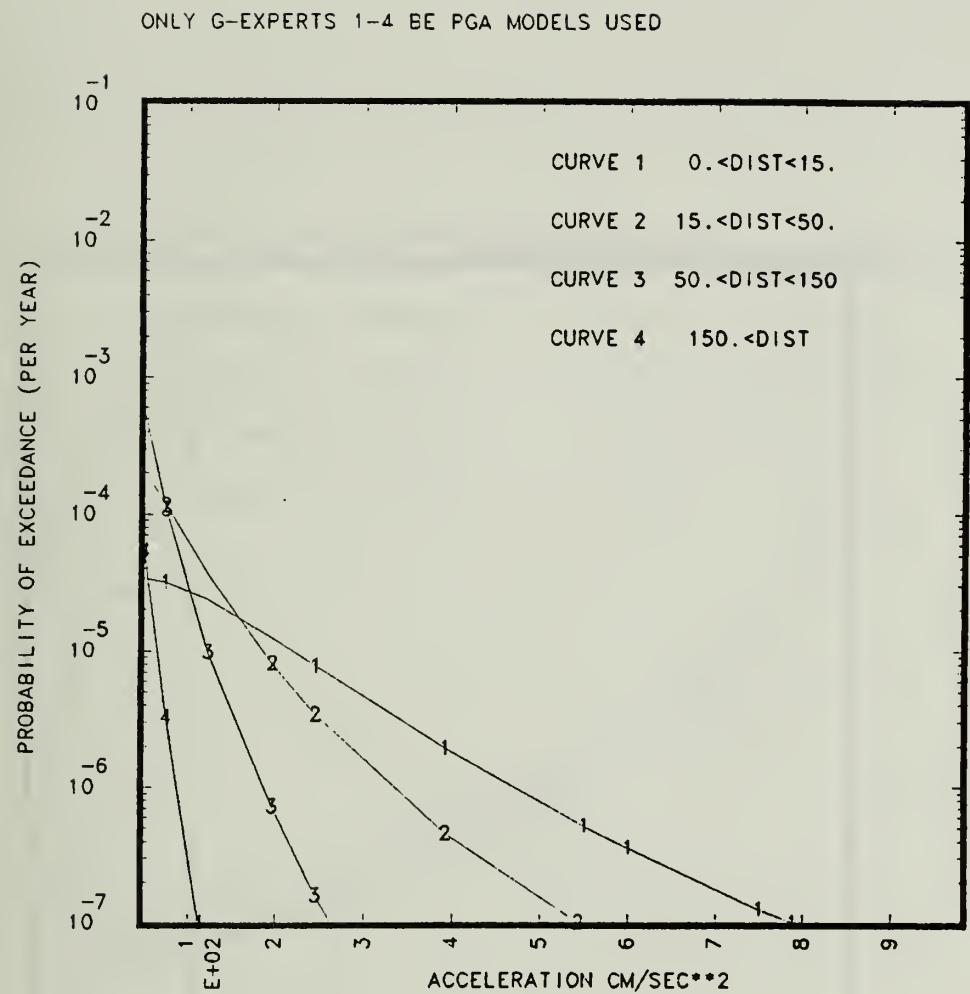


Figure 3.3.2b Same as Fig. 3.3.2a except only G-Experts 1-4 BE GM models were used.

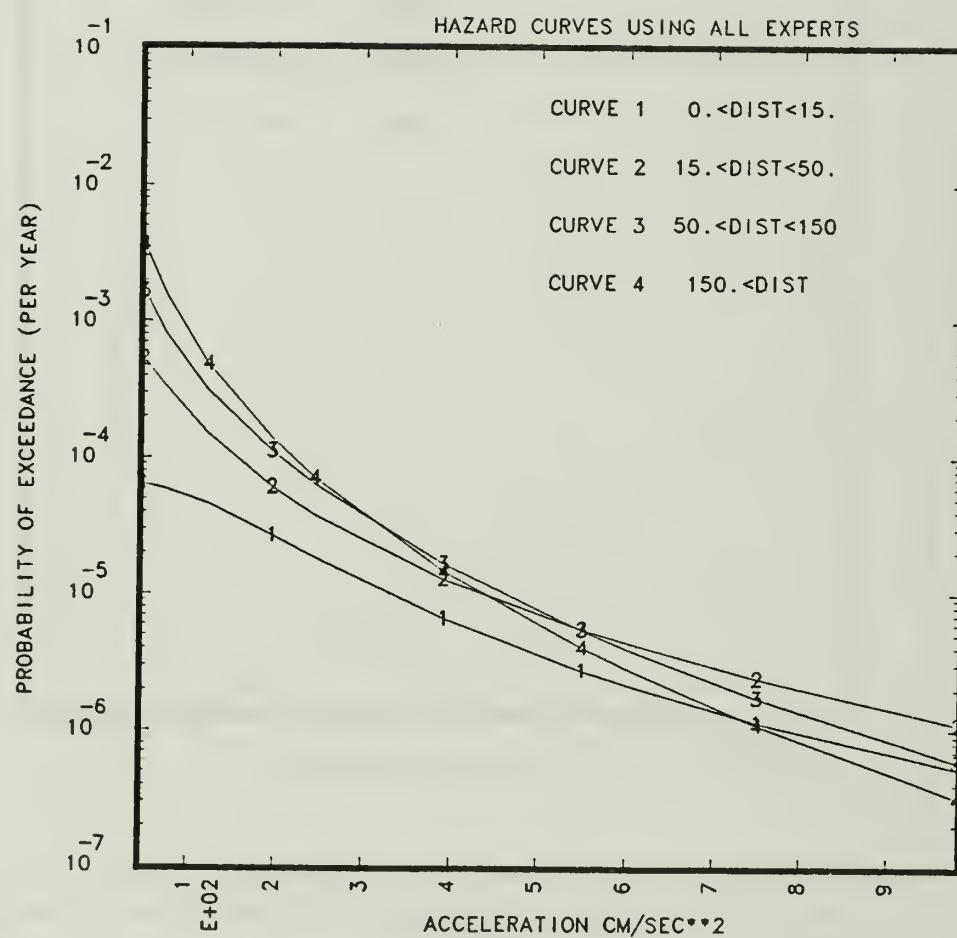


Figure 3.3.3a BEHCs for a rock site located in the northern part of region 1 which include only the contribution to the hazard for PGA from earthquakes within the indicated distance ranges.

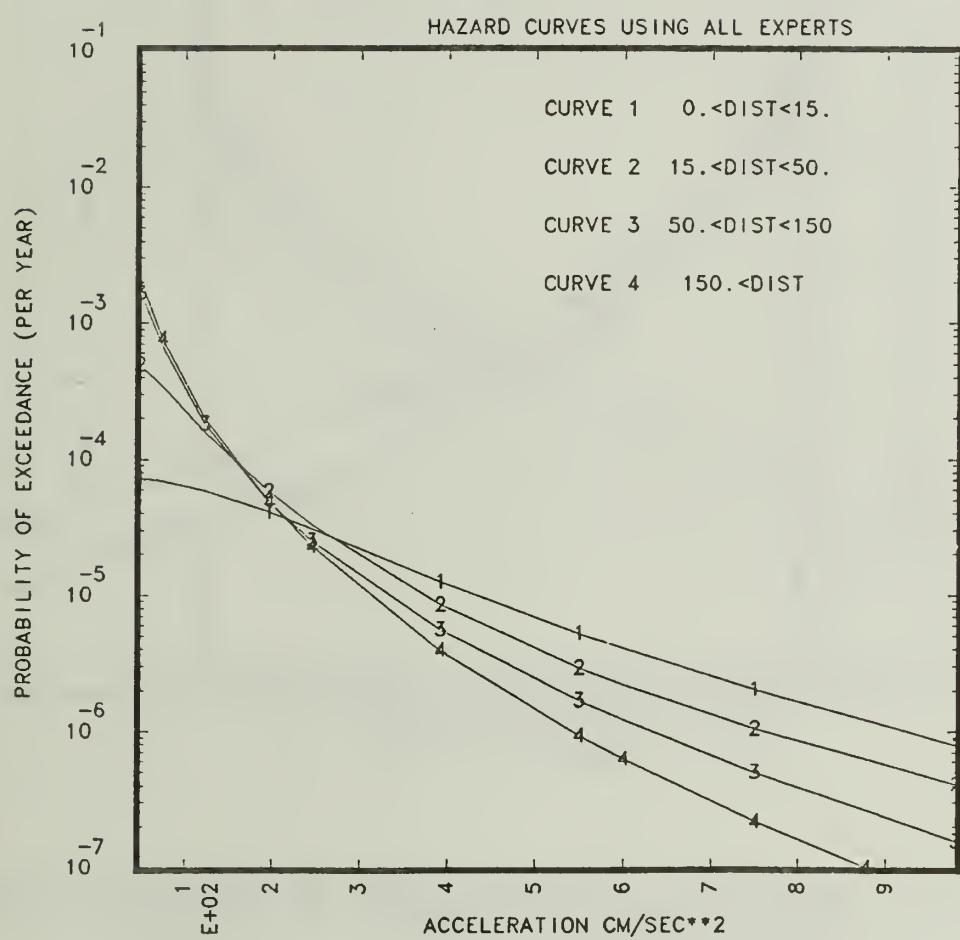


Figure 3.3.3b BEHCs for a soil site located in the northern part of region 1 which include only the contribution to the PGA hazard from the earthquakes within the indicated distance ranges.

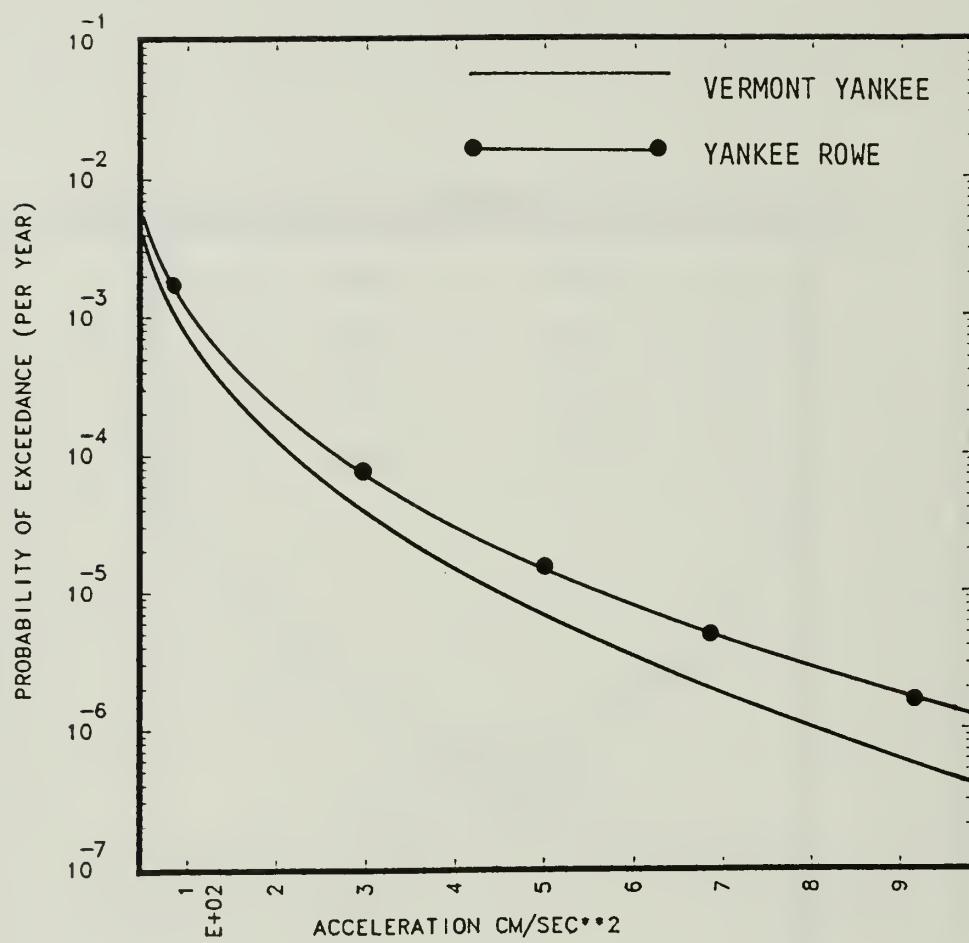


Figure 3.4.1 Comparison of the median CPHCs for PGA between the Vermont Yankee and Yankee Rowe site.

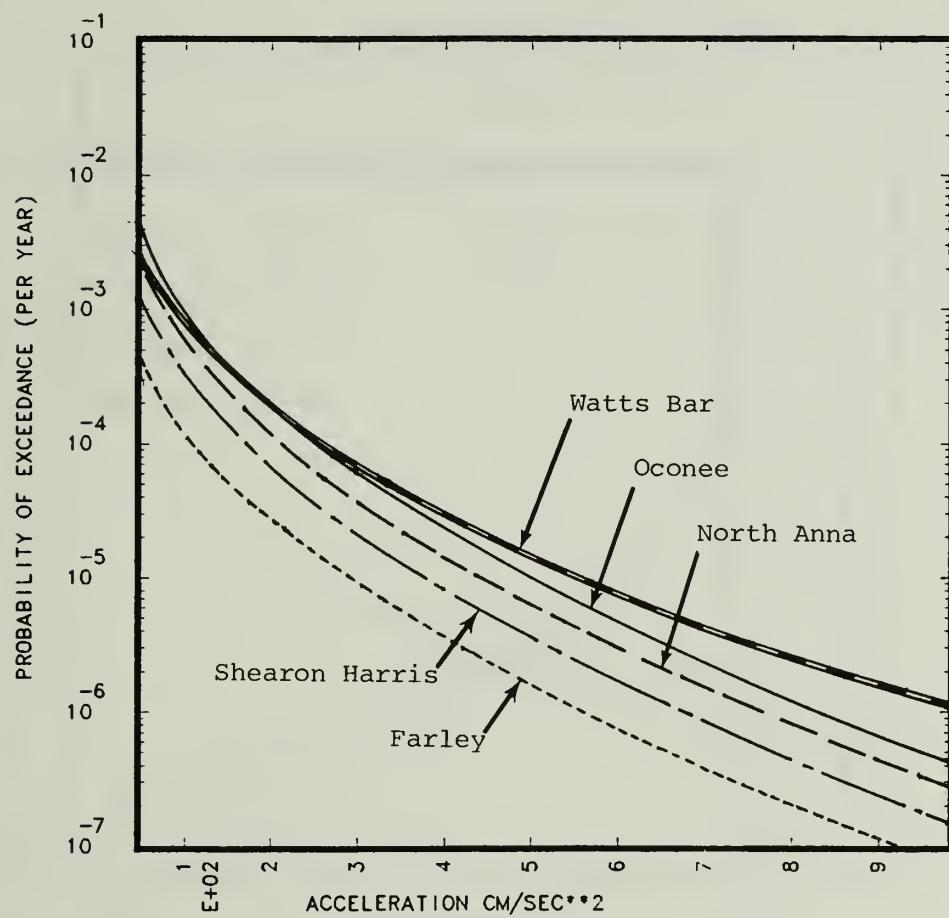


Figure 3.4.2 Comparison of the median CPHCs for PGA for 5 sites of region 2.

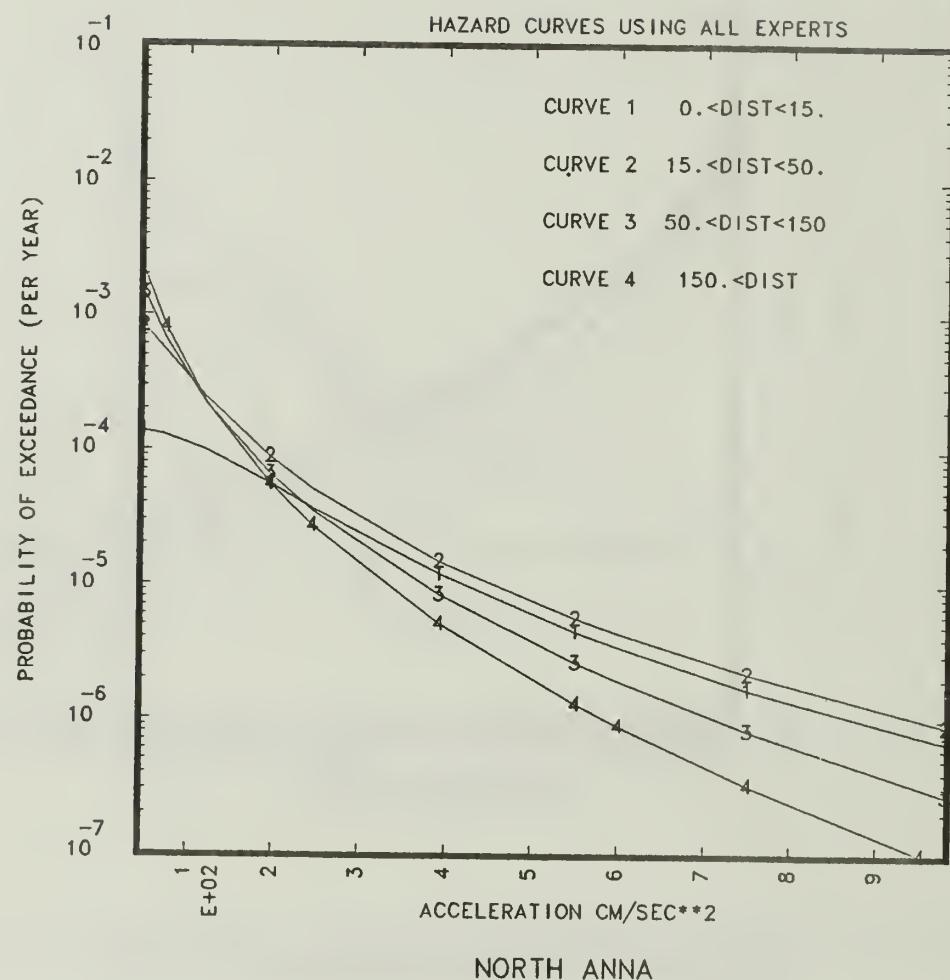


Figure 3.4.3 Contribution to the hazard from earthquakes segregated into four distance ranges, for the North Anna rock site, in terms of probability of exceedance of the PGA.

CONTRIBUTION TO THE HAZARD FOR PGA
FROM THE EARTHQUAKES IN 4 DISTANCE RANGES

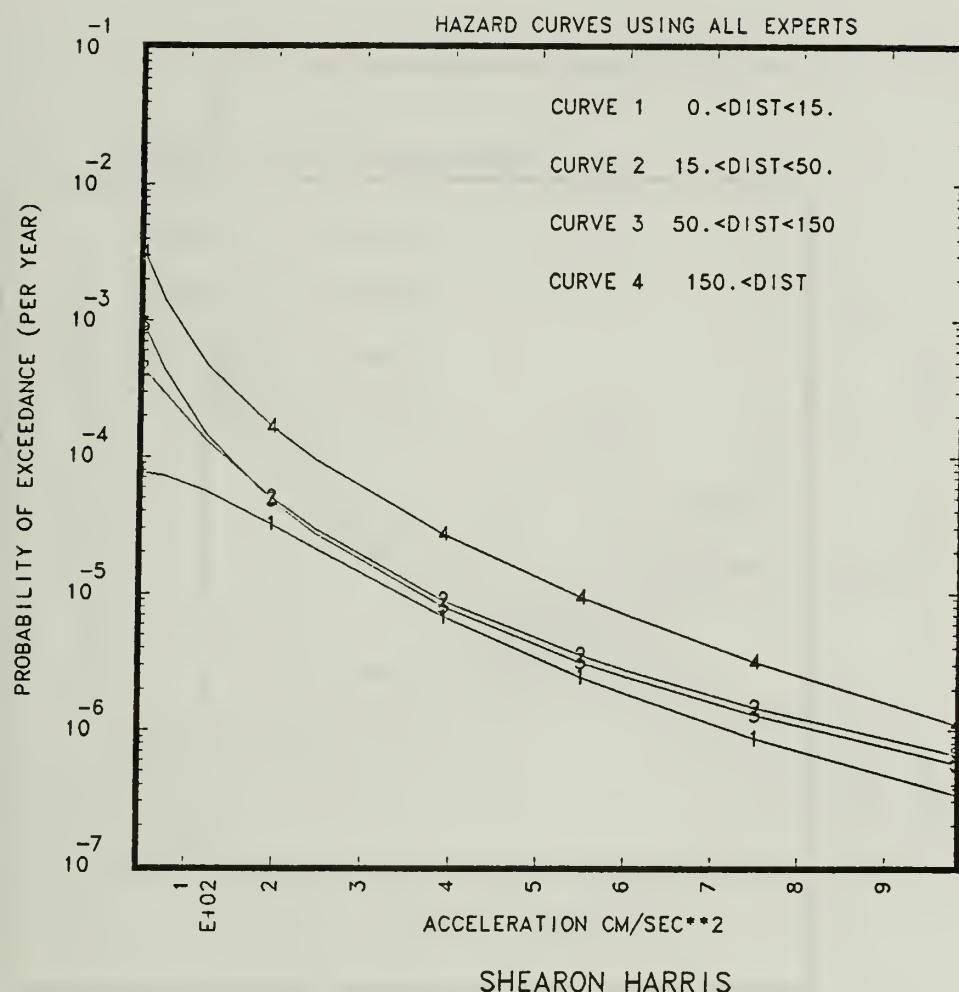


Figure 3.4.4 Contribution to the hazard from earthquakes segregated into four distance ranges, for the Shearon Harris rock site, in terms of probability of exceedance of the PGA.

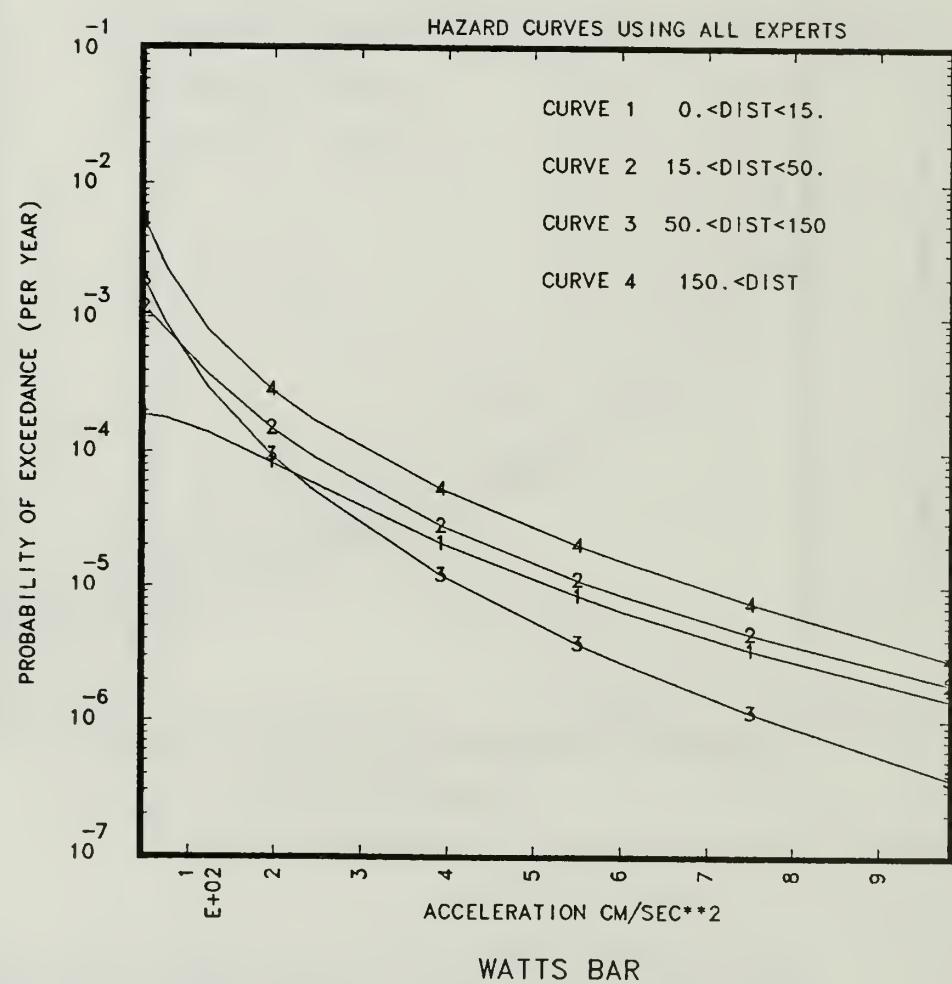


Figure 3.4.5 Contribution to the hazard from earthquakes segregated into four distance ranges, for the Watts Bar rock site, in terms of probability of exceedance of the PGA.

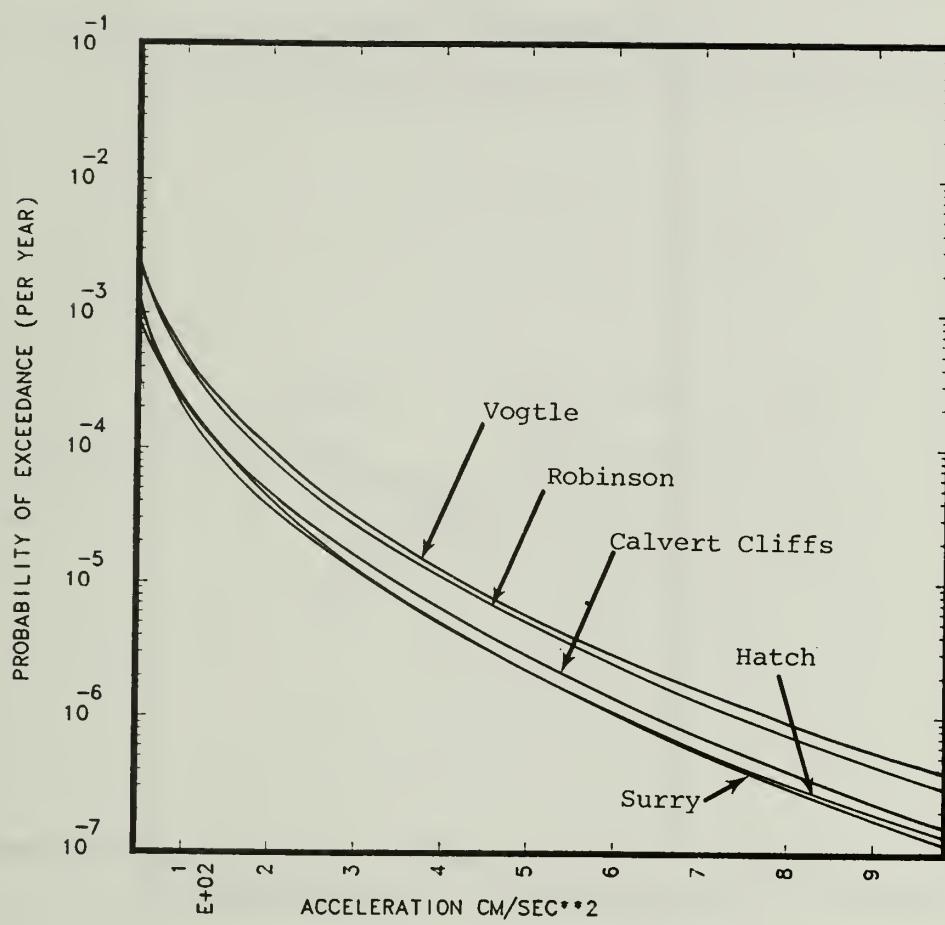


Figure 3.4.6 Comparison of the median CPHCs of five deep soil sites in region 2, in terms of probability of exceedance of the PGA.

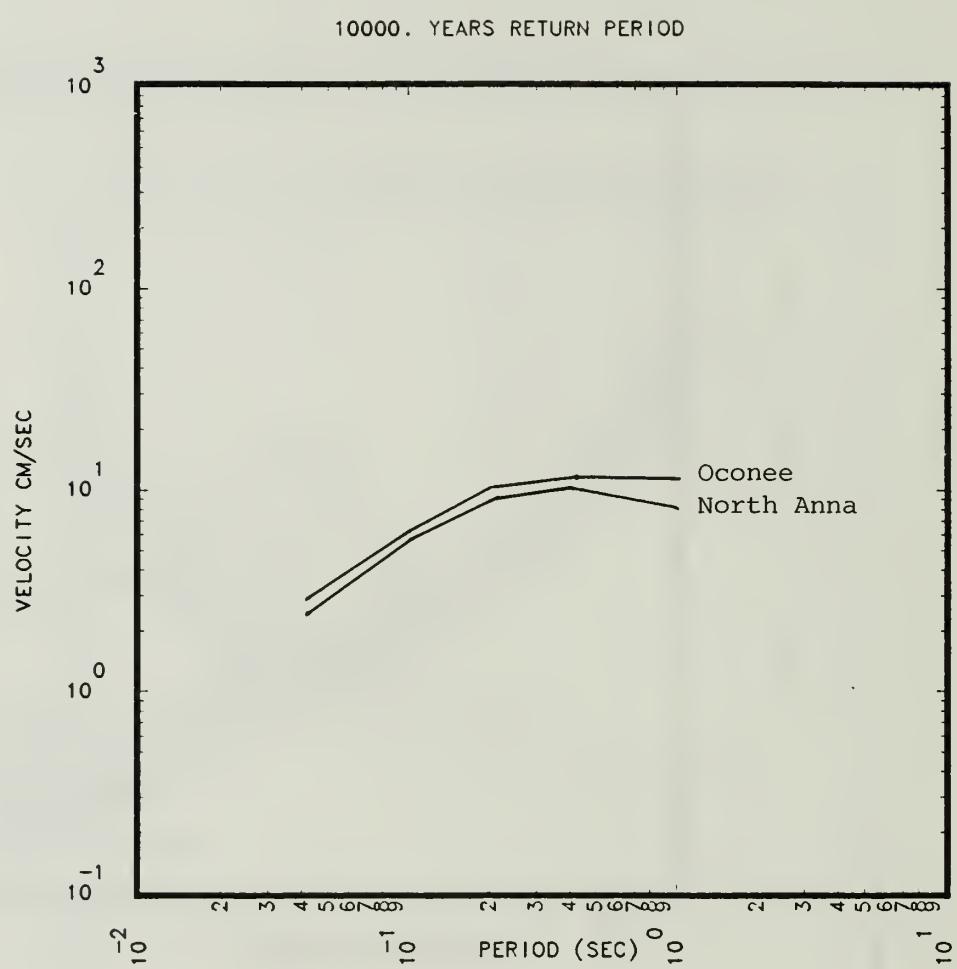


Figure 3.4.7 10,000 year, 5 percent damping median CPUHS for two sites of region 2. At North Anna the hazard is dominated by small earthquakes and at Oconee, the hazard is dominated by large earthquakes.

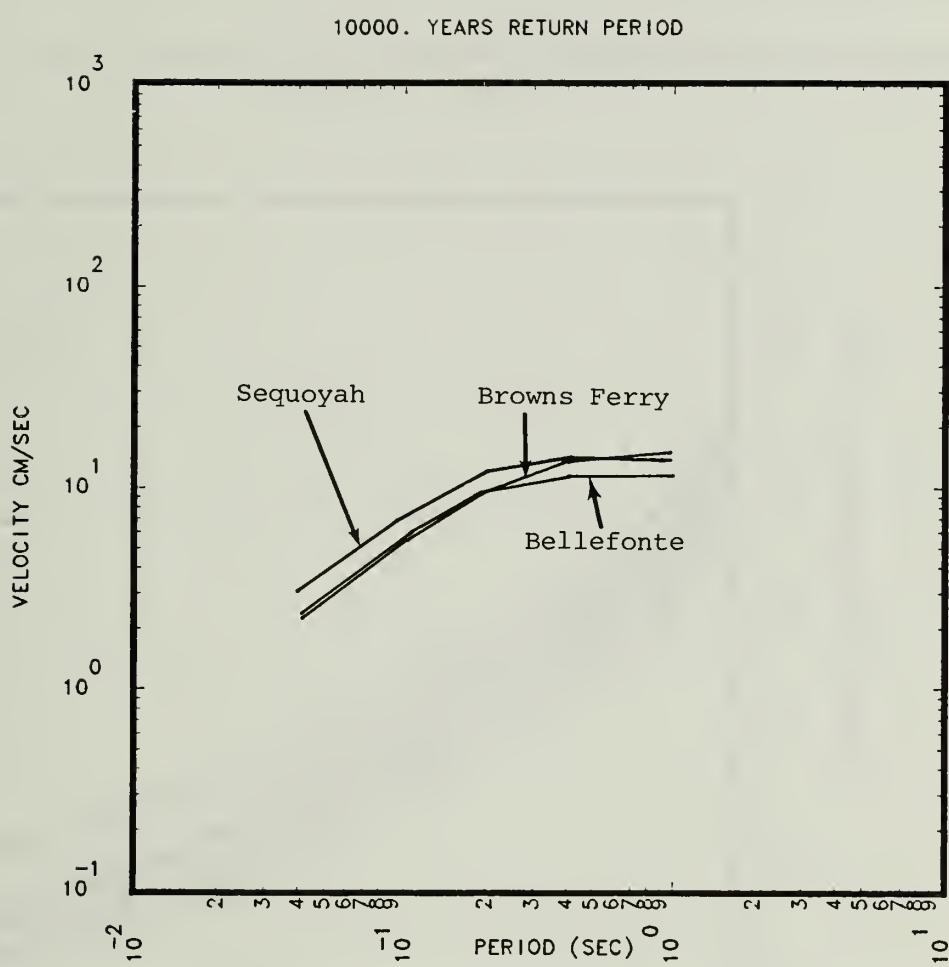


Figure 3.4.8 10,000 year, 5 percent damping median CPUHS for four plant sites in a part of region 2 dominated by the New Madrid area.

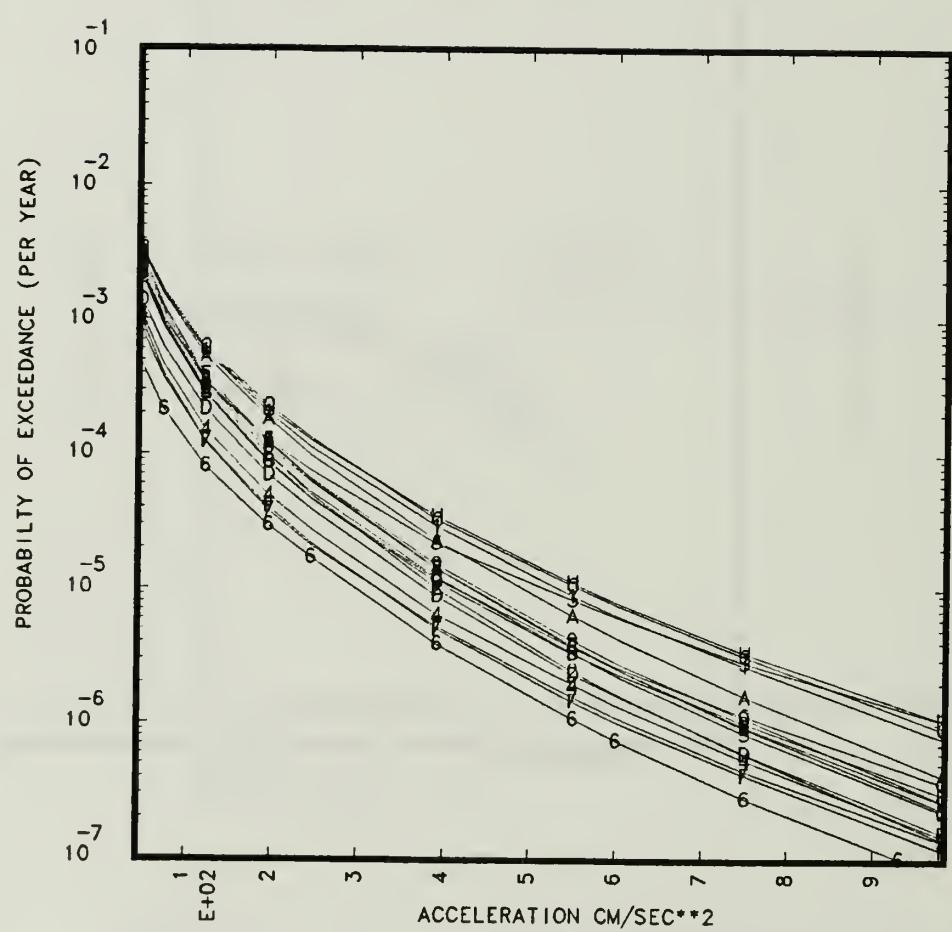


Figure 3.4.9 Median CPHCs for all the sites in Batch 2. The plot symbols for the sites are the same as given in Table 1.1.

LOG OF ANNUAL PROB. OF EXCEEDANCE

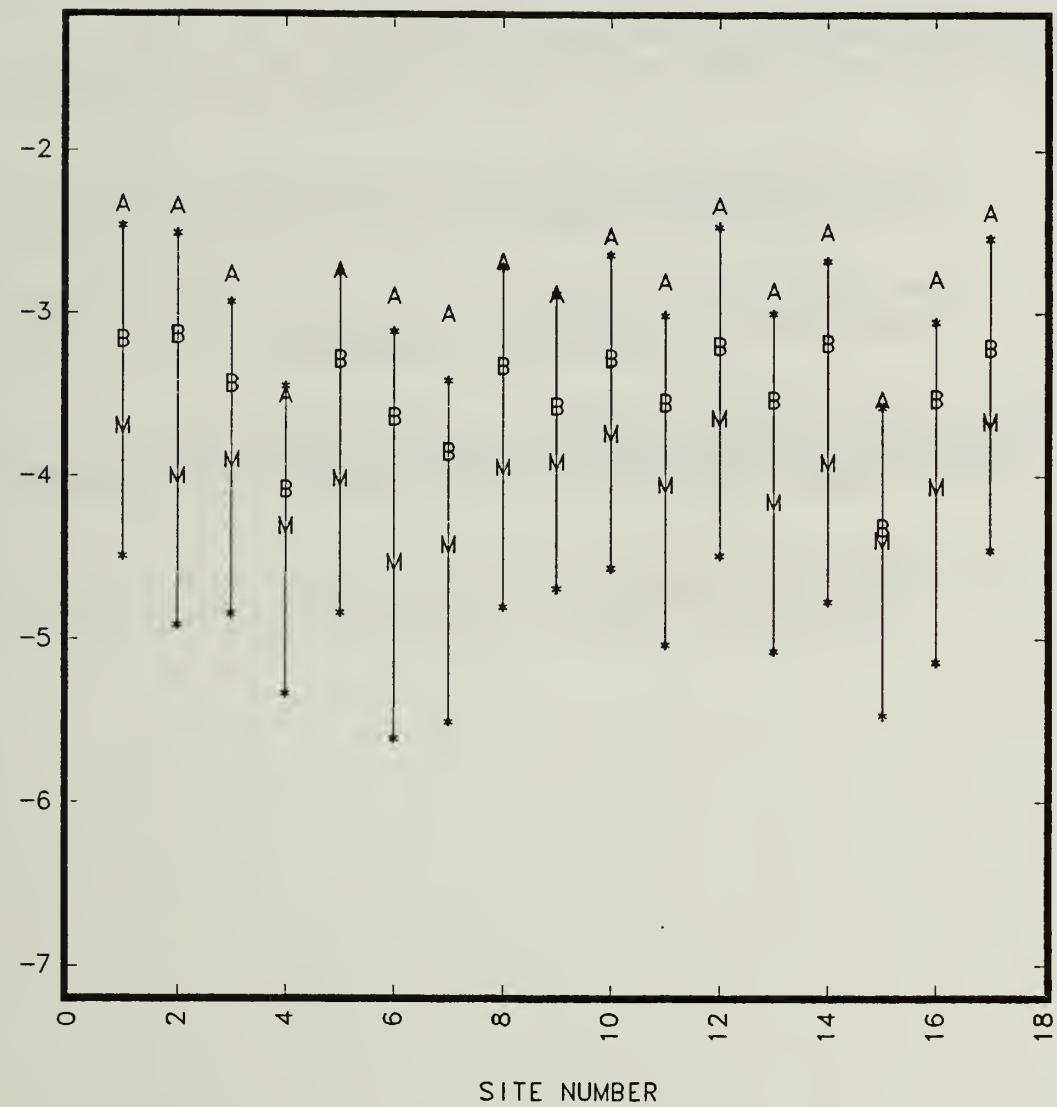
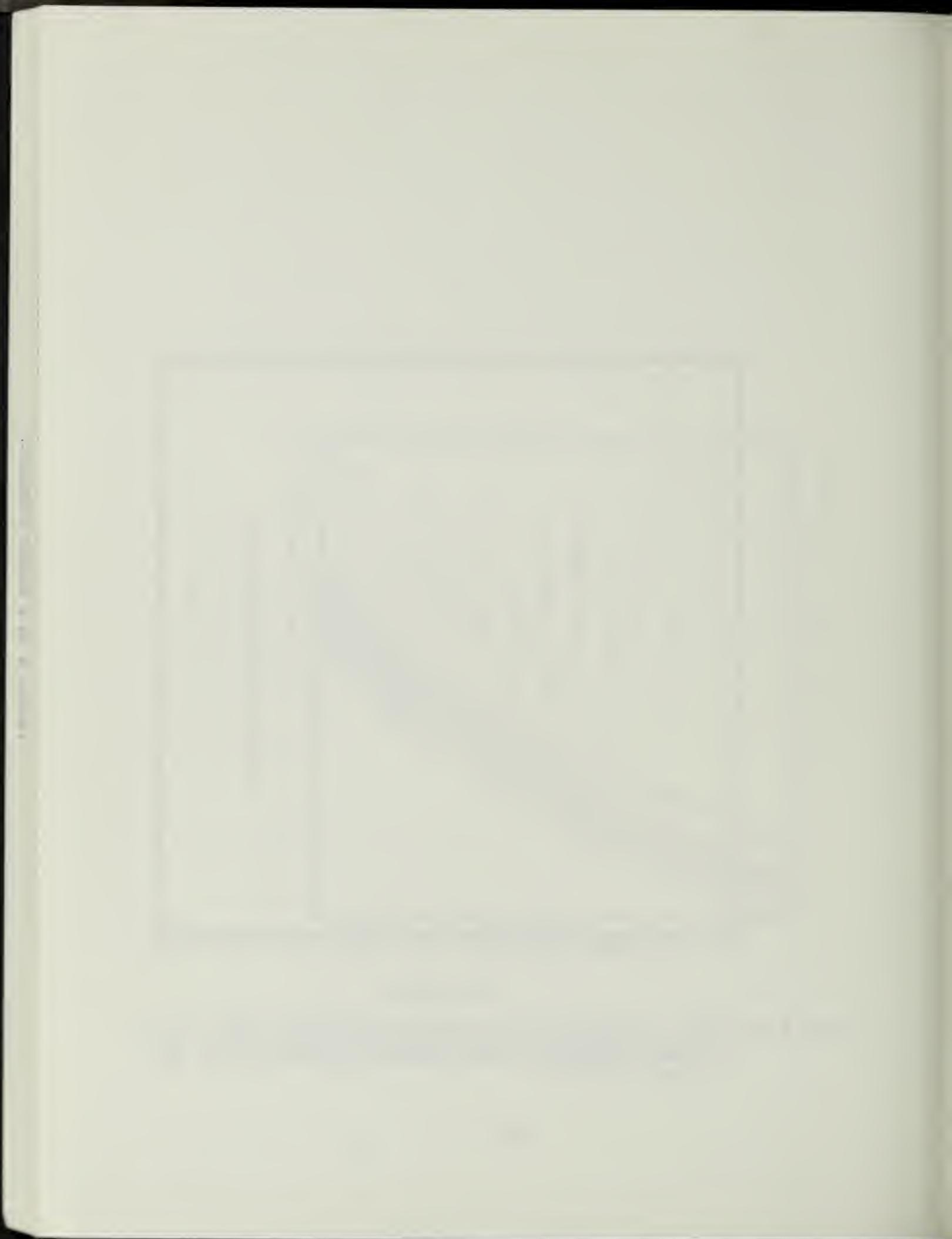


Figure 3.4.10 Median (M) probability of exceedance of 0.2g, arithmetic mean (A), best estimate (B), 15th and 85th percentiles (*) for the 17 sites of Batch 2.



APPENDIX A

References

Algermissen, S.T., Perkins, D.M., Thenhaus, P.C., Hangen, S.L., and Bender, B.L.K (1982), Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States, USGS, open file report 821033.

Bernreuter, D.L. and Minichino, C. (1983), Seismic Hazard Analysis Overview and Executive Summary, NUREG/CR-1582, Vol. 1 (UCRL-53030).

Bernreuter, D.L., Savy, J.B., and Mensing, R.W. (1987), Seismic Hazard Characterization of the Eastern United States: Comparative Evaluation of the LLNL and EPRI Studies, U.S. NRC Report NUREG/CR-4885.

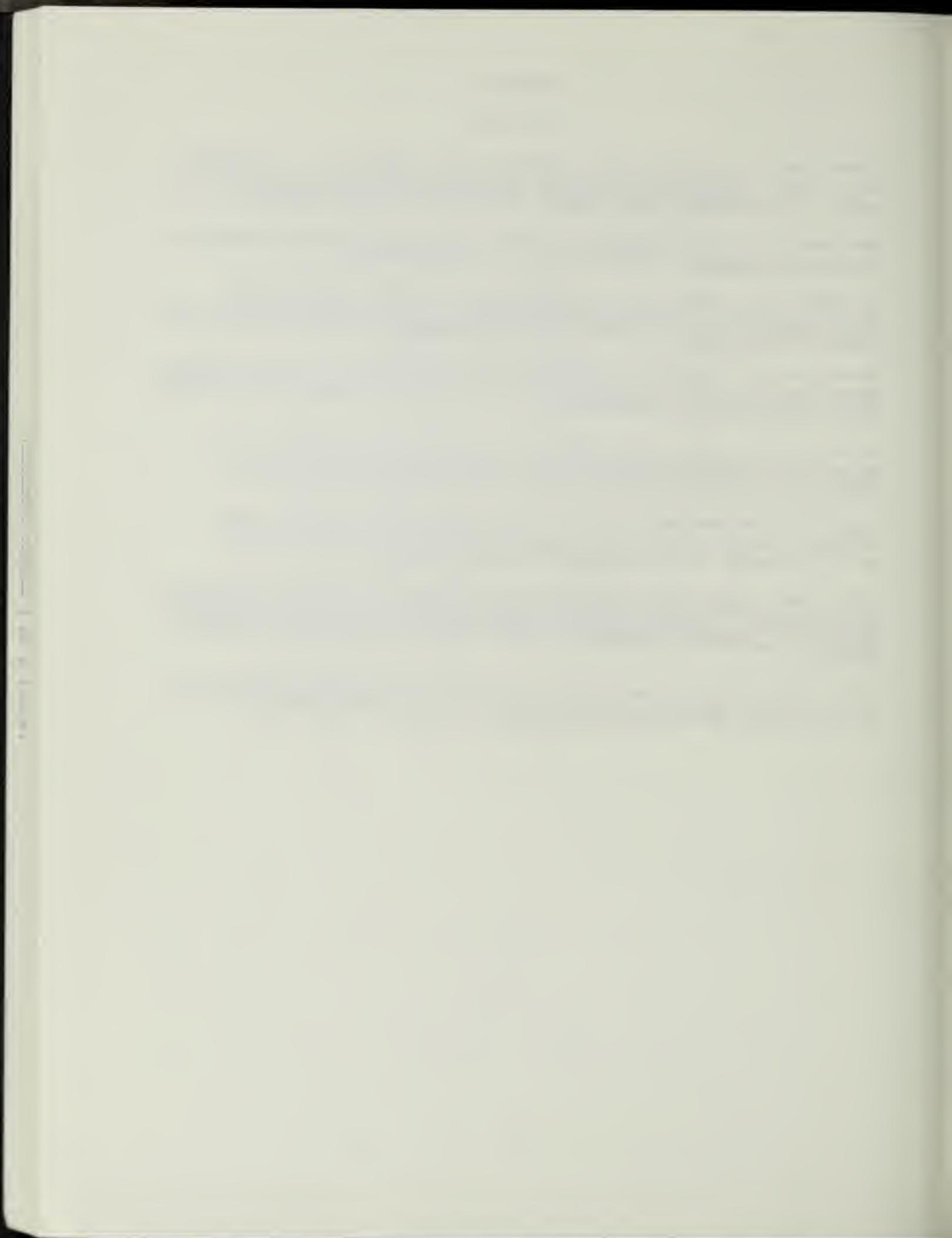
Bernreuter, D.L., Savy, J.B., Mensing, R.W., and Chung, D.H. (1984), Seismic Hazard Characterization of the Eastern United States: Methodology and Interim Results for Ten Sites, NUREG/CR-3756.

Bernreuter, D.L., Savy, J.B., Mensing, R.W., Chen, J.C., and Davis, B.C., Seismic Hazard Characterization of the Eastern United States, Volume 1: Methodology and Results for Ten Sites, UCID-20421, Vols. 1 and 2.

Chung, D.H. and Bernreuter, D.L., (1981), "Regional Relationships Among Earthquake Magnitude Scales," Reviews of Geophysics and Space Physics, Vol. 19, 649-663, see also NUREG/CR-1457 (UCRL-52745).

EPRI (1985), Seismic Hazard Methodology for Nuclear Facilities in the Eastern United States: Preliminary Seismic Hazard Test Computations for Parametric Analysis and Comparative Evaluations, EPRI Research Project Number P101-2g (Draft).

EPRI (1986) (Electric Power Research Institute), Seismic Hazard Methodology for the Central and Eastern United States, 9 Volumes, EPRI-NP-4726.



APPENDIX B

Maps of Seismic Zonations for Each
of the 11 S-Experts

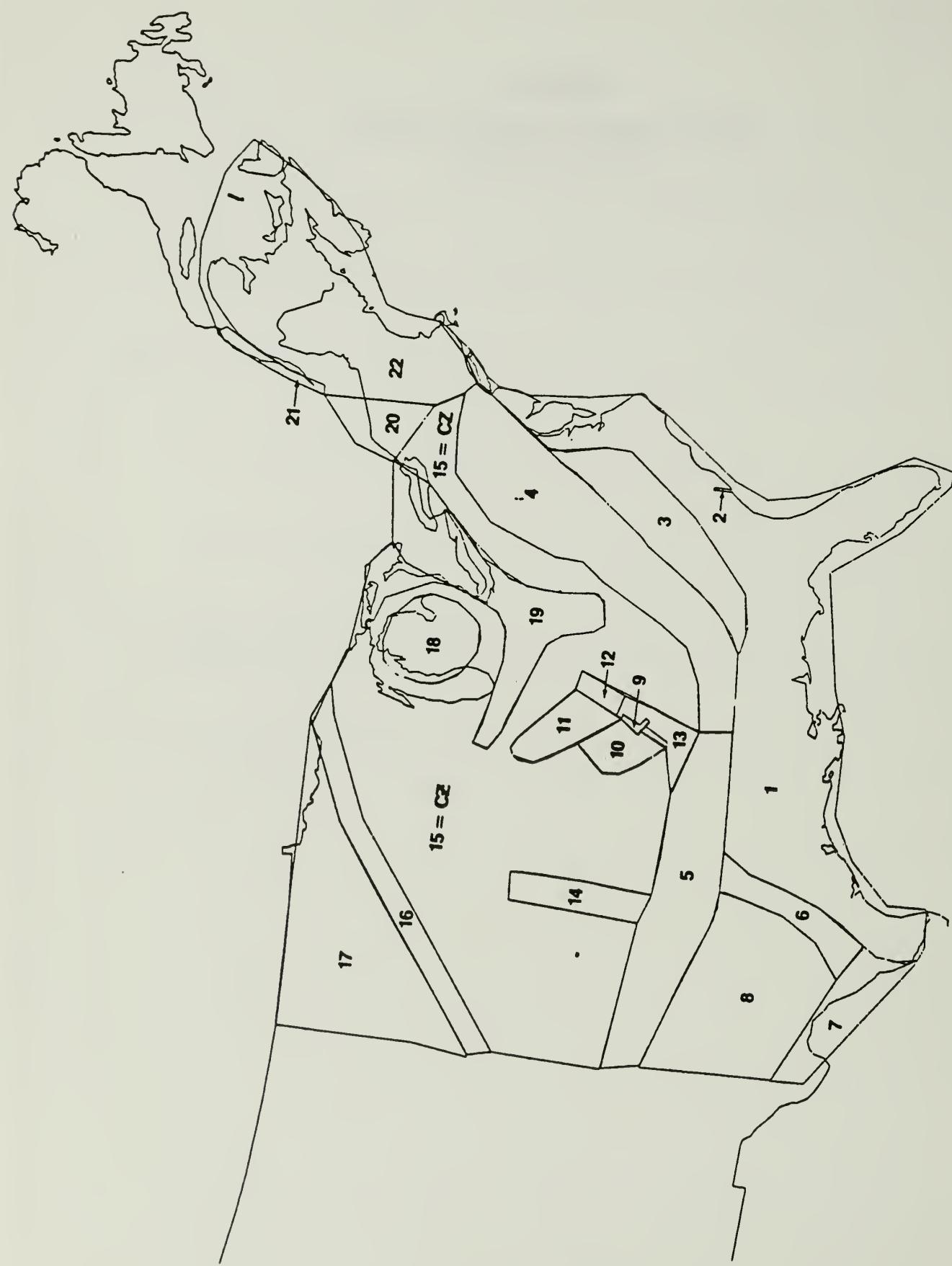


Figure B1.1 Seismic zonation base map for Expert 1.

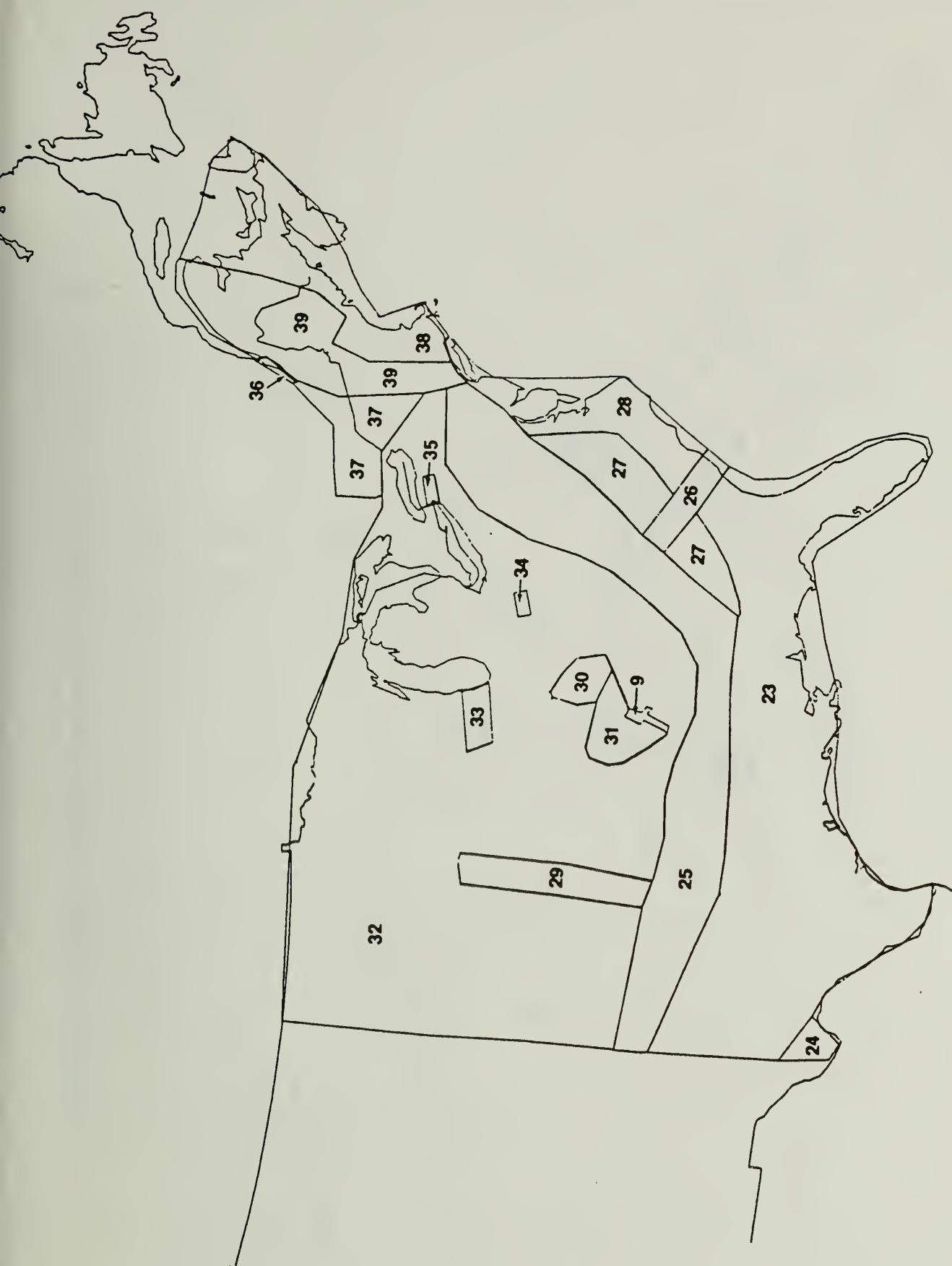


Figure B1.2 Map of alternative seismic zonation to Expert 1's base map.



Figure B2.1 Seismic zonation base map for Expert 2.

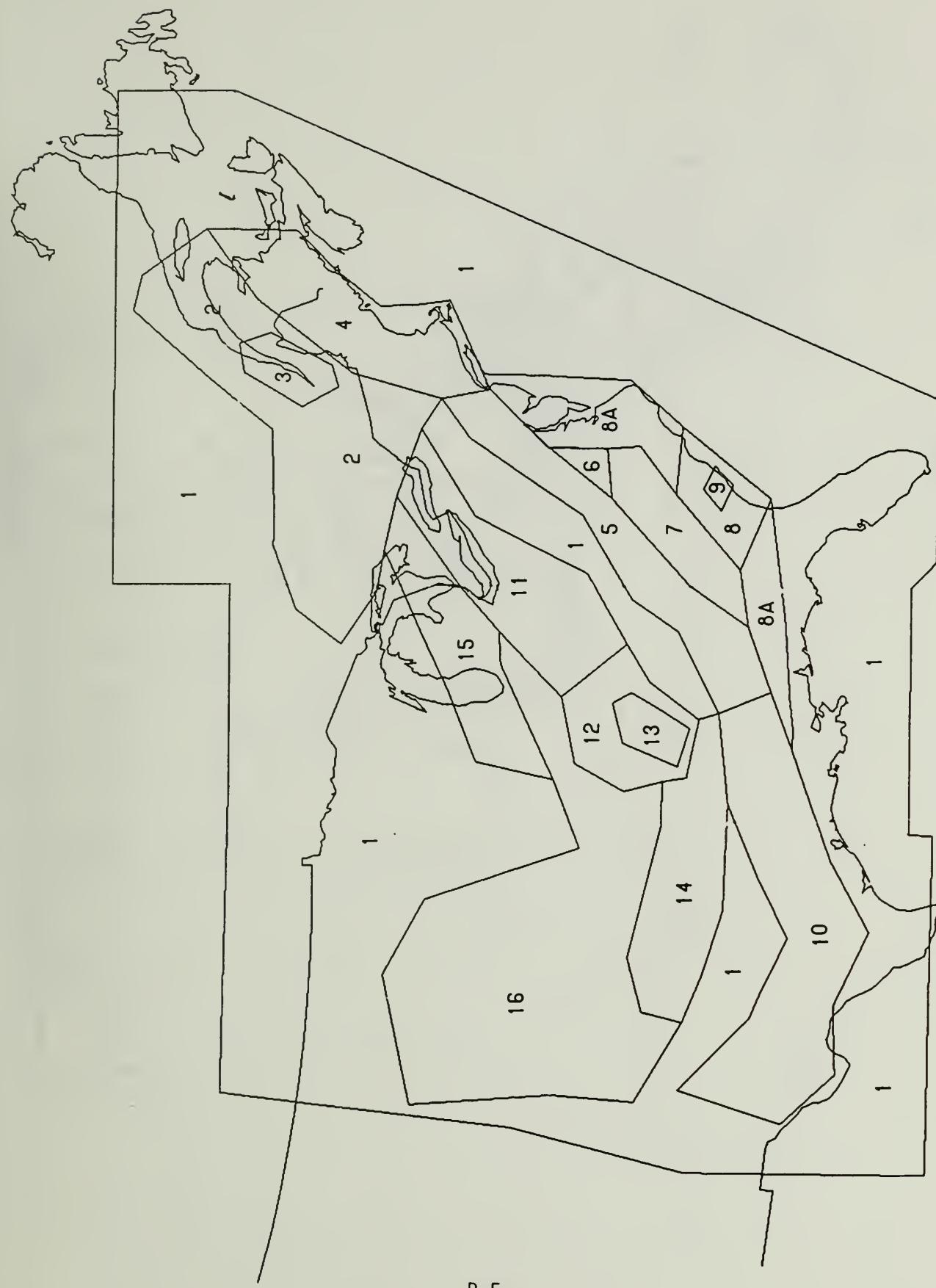


Figure B3.1 Seismic zonation base map for Expert 3.



Figure B4.1 Seismic zonation base map for Expert 4.

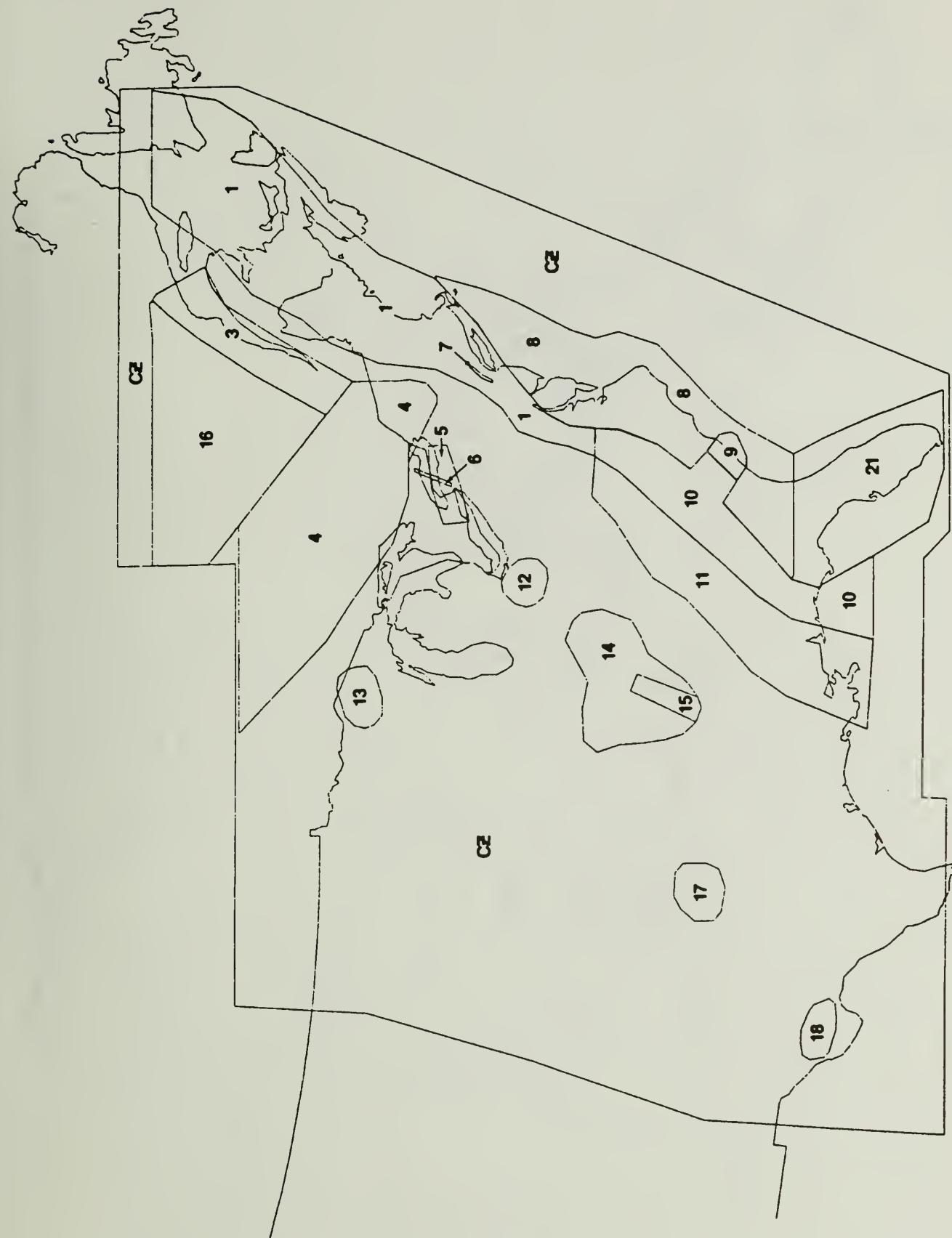


Figure B5.1 Seismic zonation base map for Expert 5

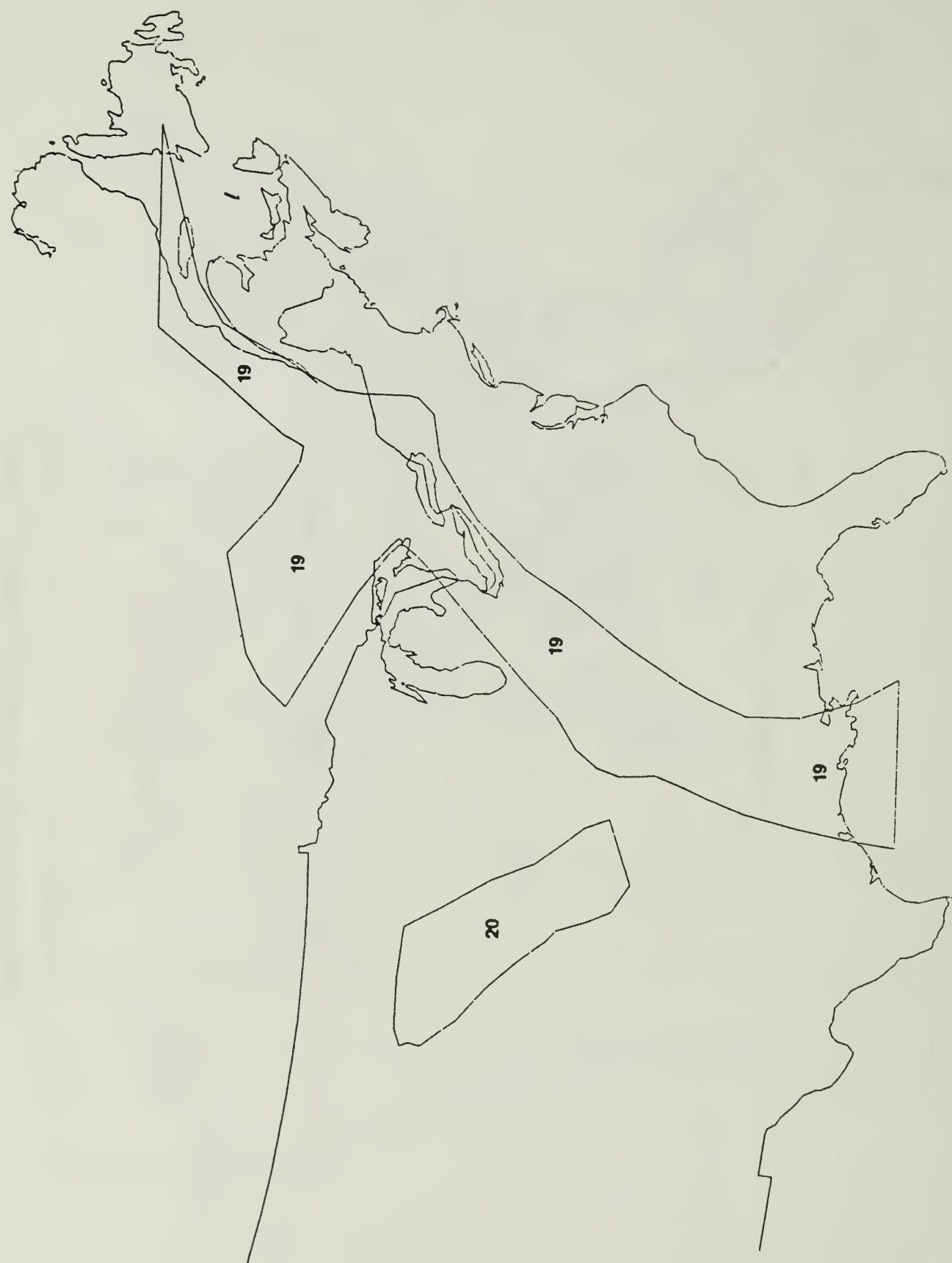


Figure B5.2 Map of alternative seismic zonations to Expert 5's base map.

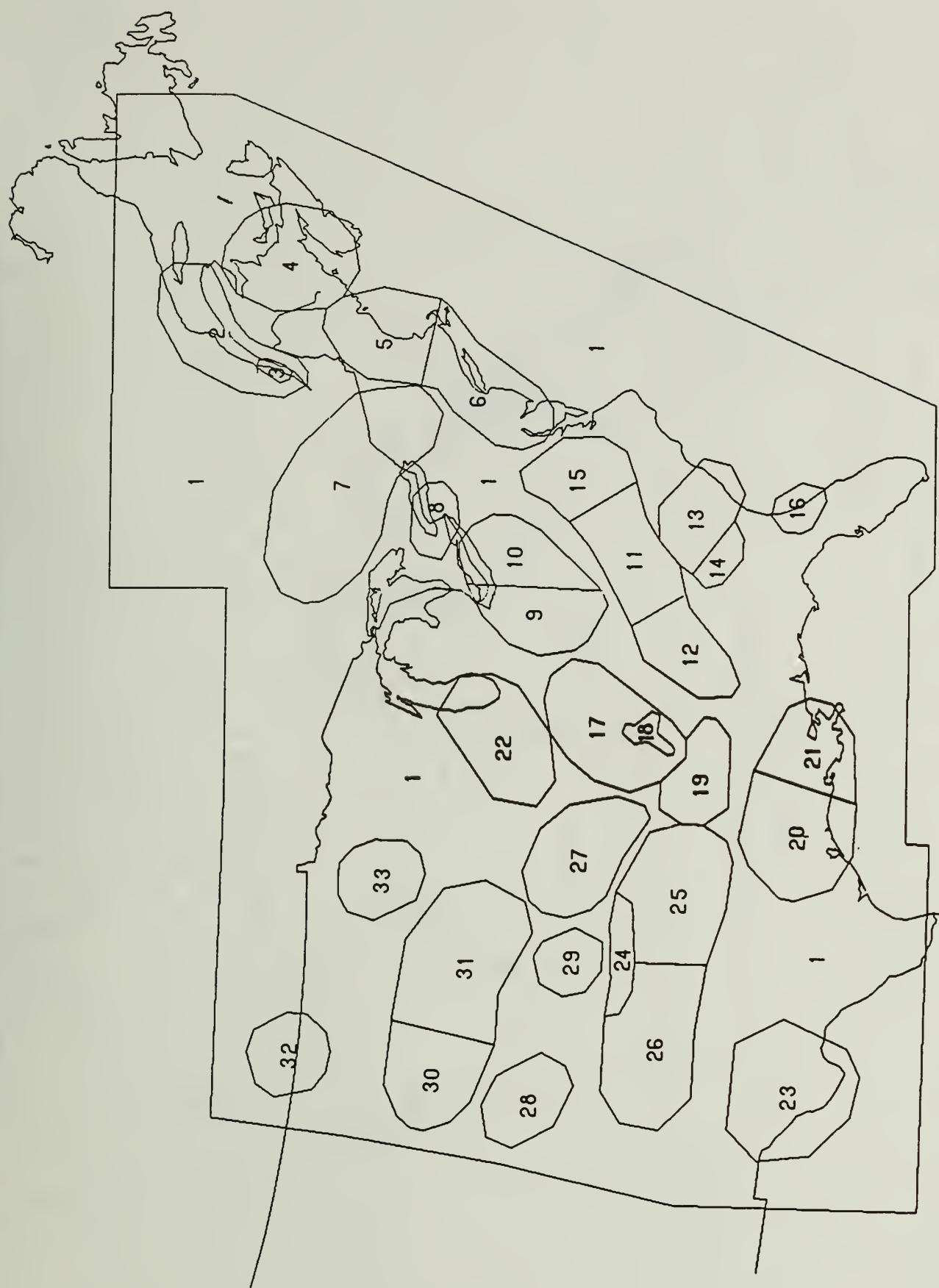


Figure B6.1 Seismic zonation base map for Expert 6

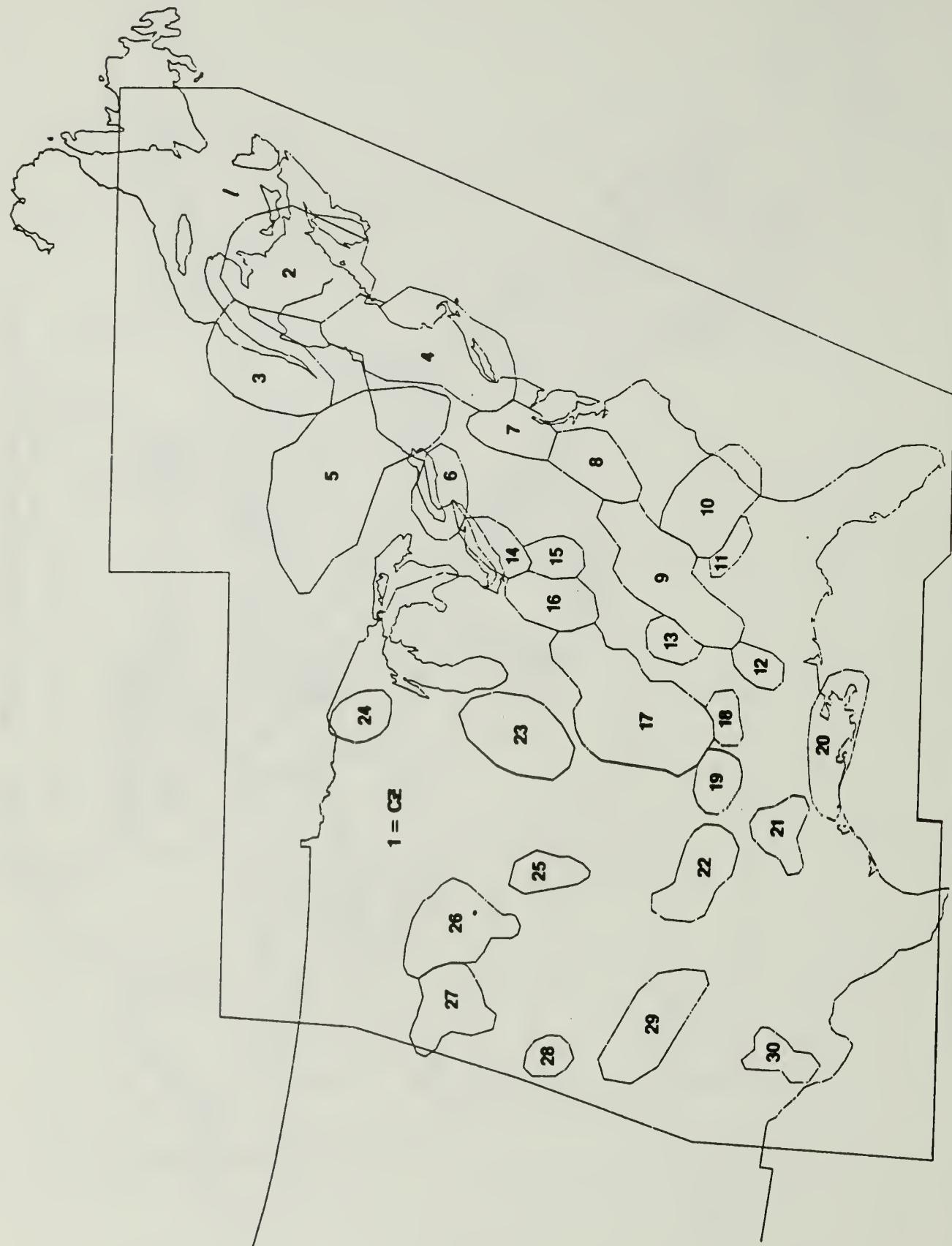


Figure B6.2 Seismic zonation map alternative 1 to Expert 6's base map.

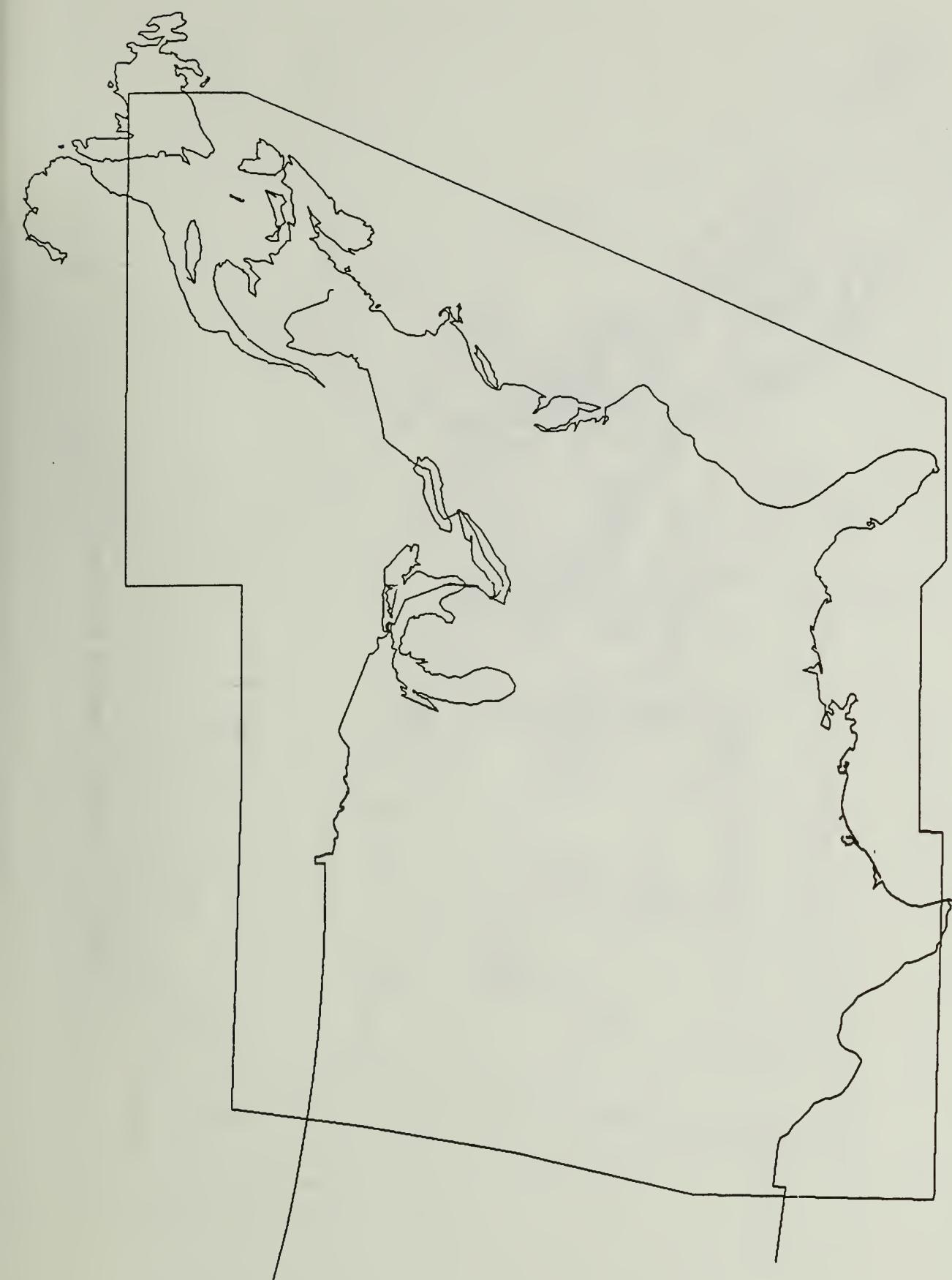


Figure B6.3 Seismic zonation map alternative 2 to Expert 6's base map.

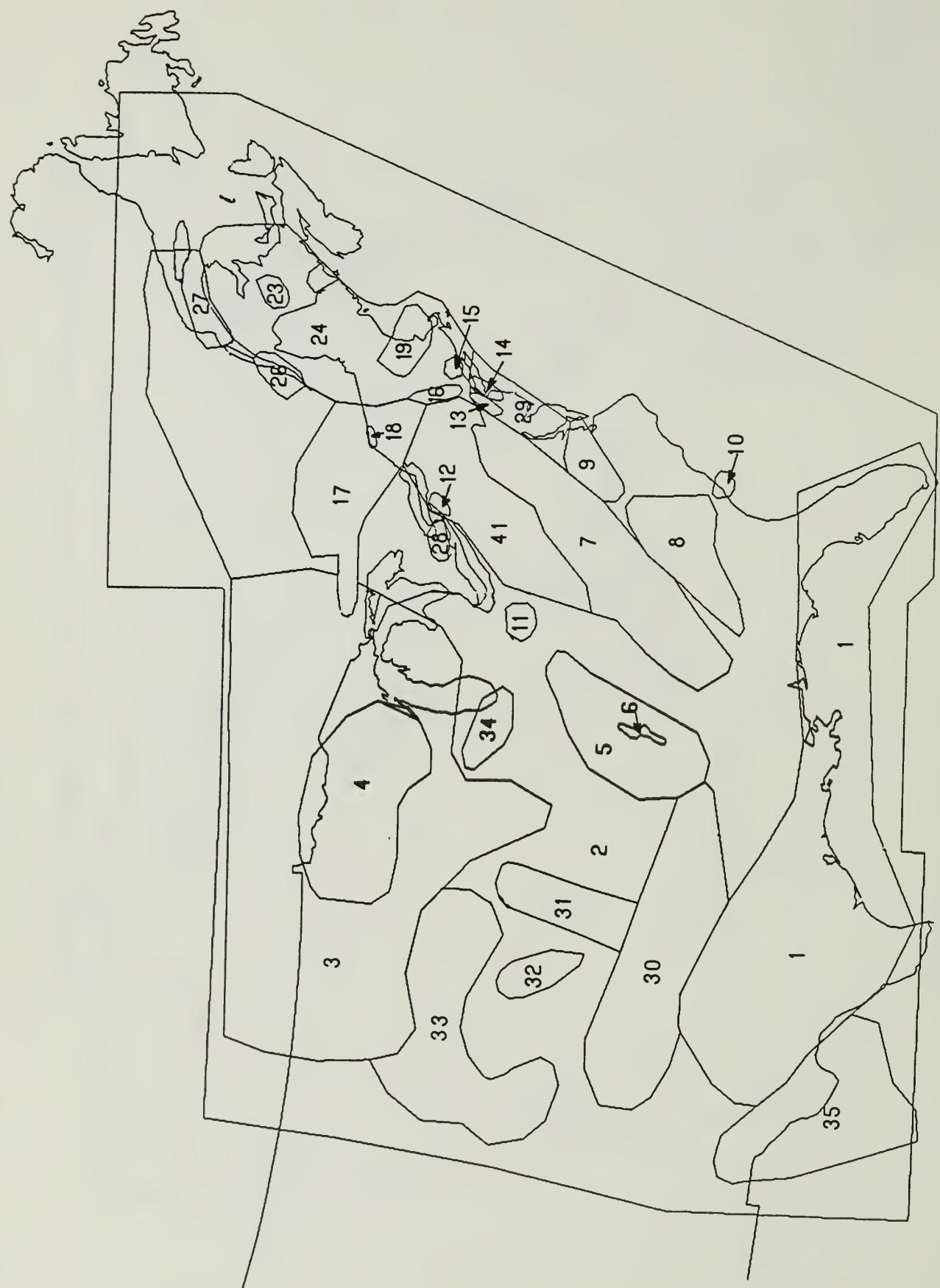


Figure 7.1 Seismic zonation base map for Expert 7.

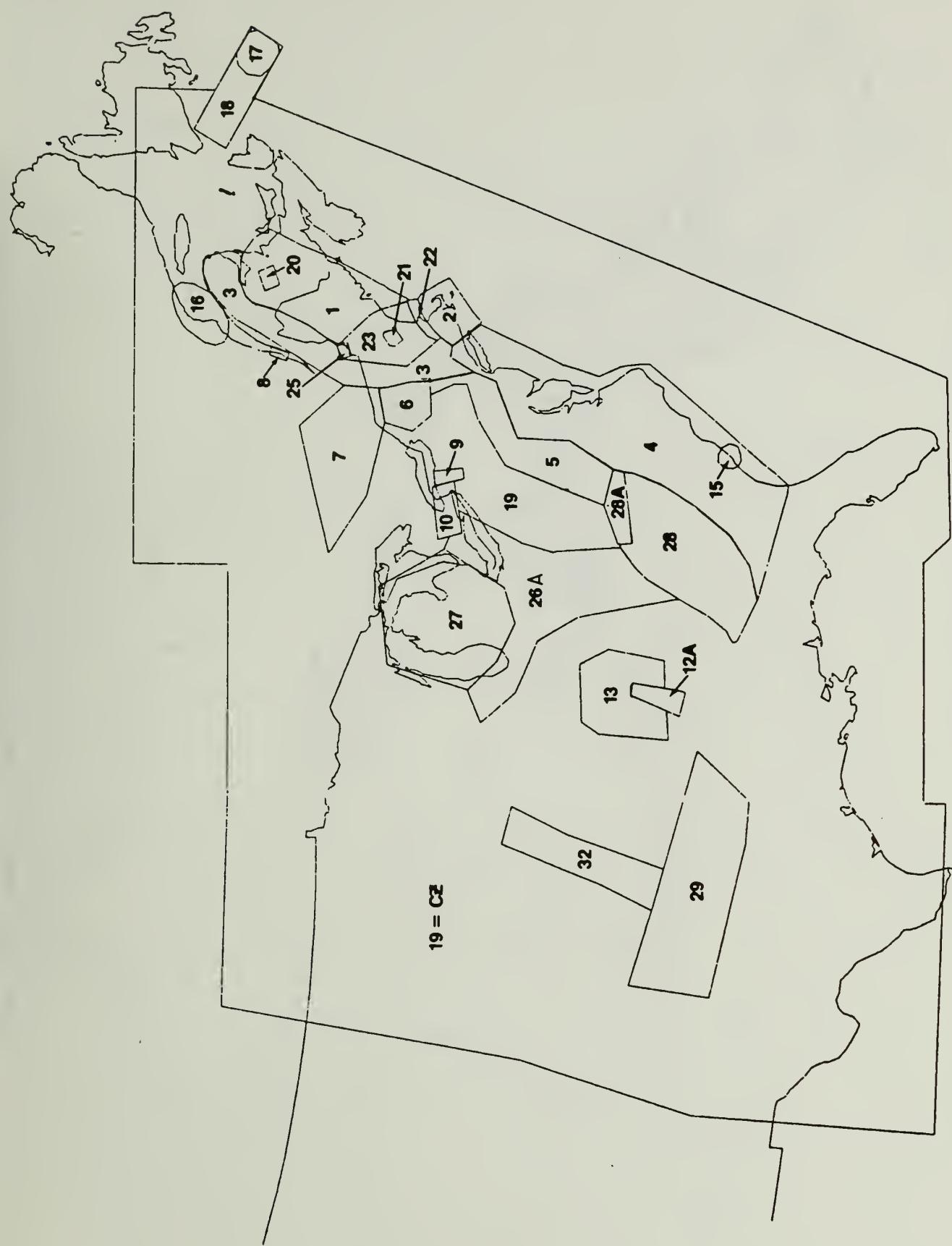


Figure B10.1 Seismic zonation base map for Expert 10.



Figure B10.2 Map of alternative seismic zonations to Expert 10's base map.

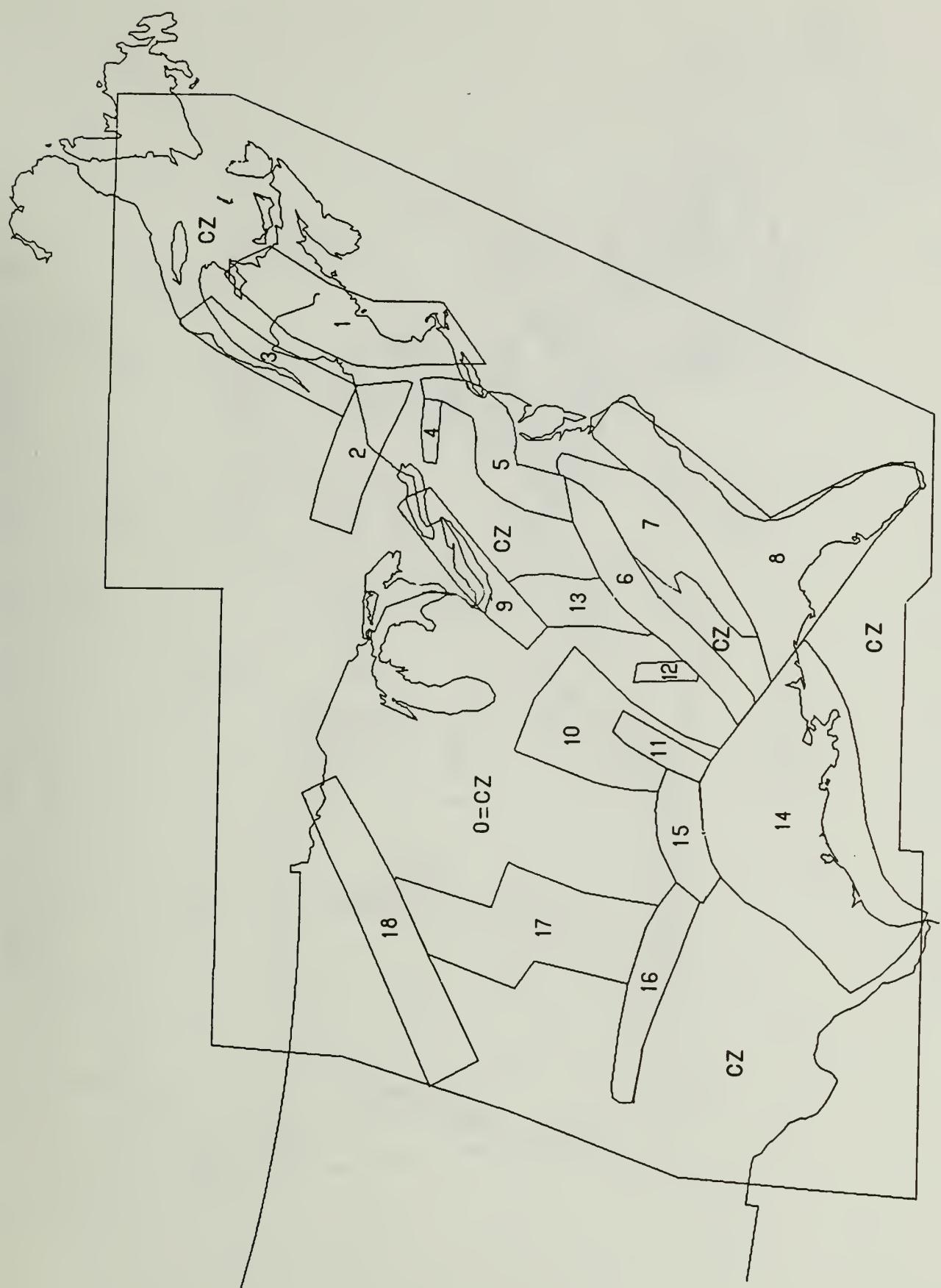


Figure B11.1 Seismic zonation base map for Expert 11.

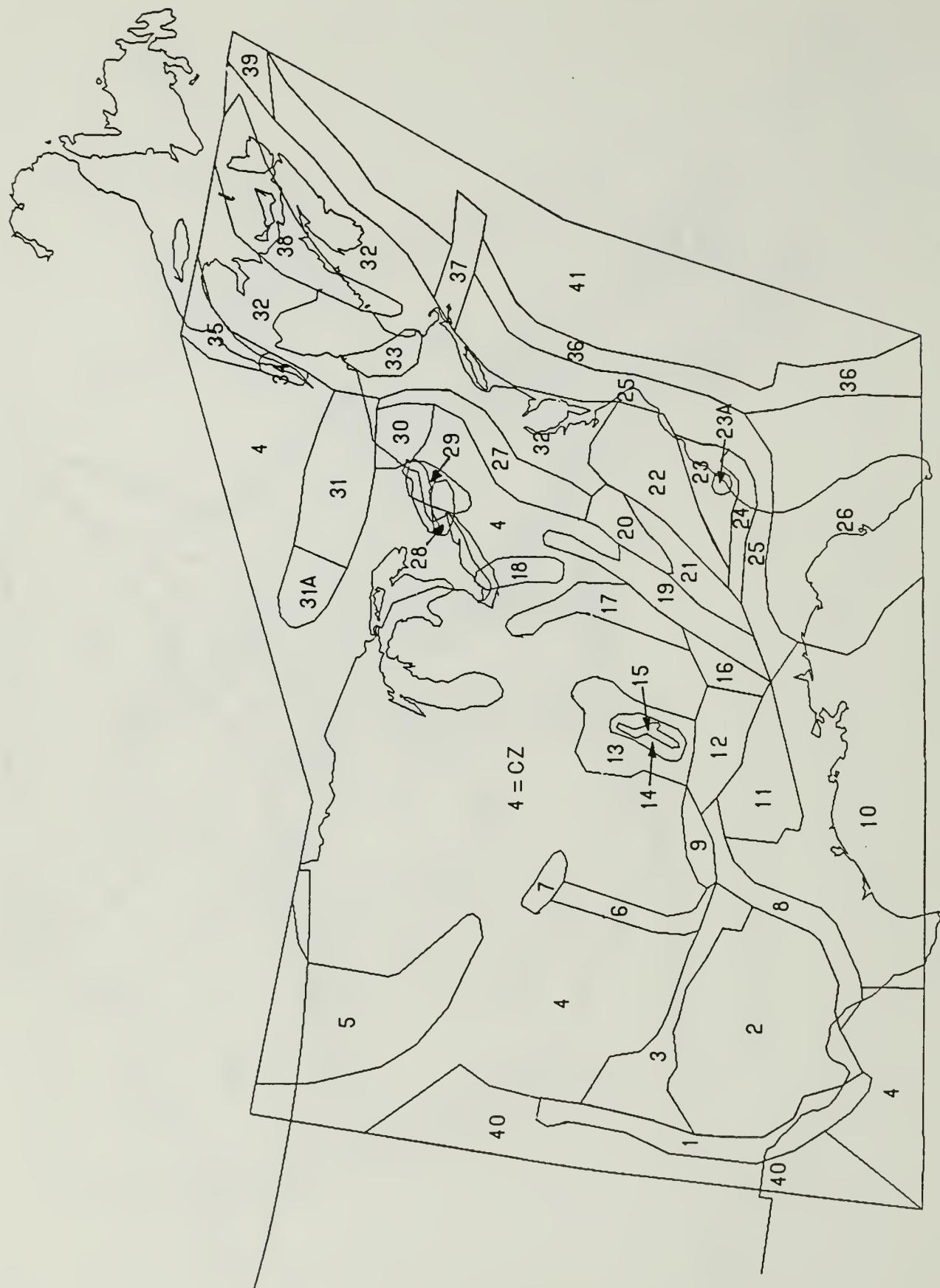
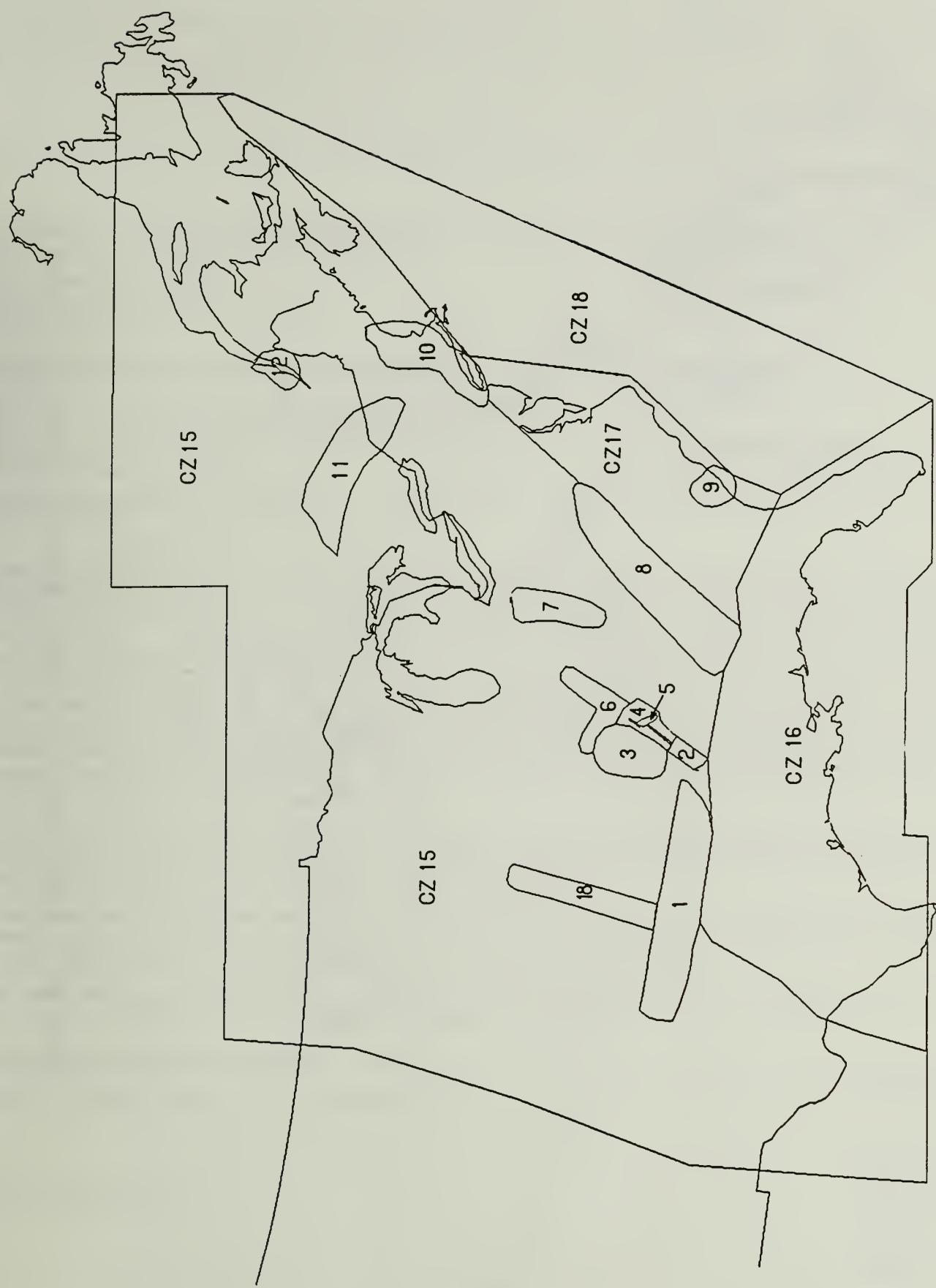


Figure B12.1 Seismic zonation base map for Expert 12.



B-17

Figure B13.1 Seismic zonation base map for Expert 13.

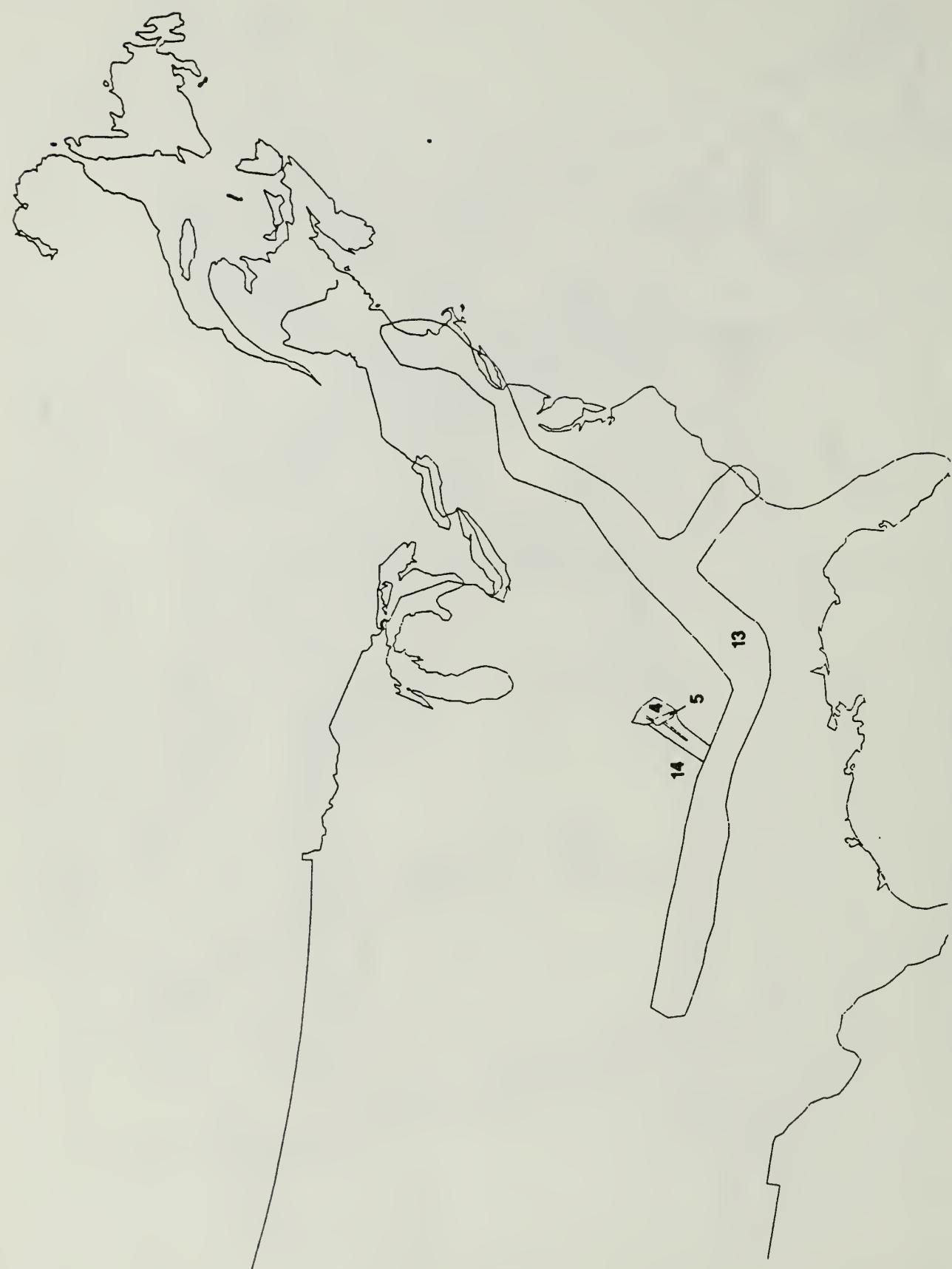


Figure B13.2 Map of alternative seismic zonations to Expert 13's base map.

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

2. TITLE AND SUBTITLE

Seismic Hazard Characterization of 69 Nuclear Plant Sites
East of the Rocky Mountains
Results and Discussion for the Batch 2 Sites

1 REPORT NUMBER (Assigned by TIDC, and Vol No., if any)

NUREG/CR-5250
UCID-21517
Vol. 3

3 LEAVE BLANK

4 DATE REPORT COMPLETED

MONTH	YEAR
November	1988

5 DATE REPORT ISSUED

MONTH	YEAR
January	1989

6. AUTHOR(S)

D.L. Bernreuter, J.B. Savy, R.W. Mensing, J.C. Chen

7. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)

Lawrence Livermore National Laboratory
P.O. Box 808, L-197
Livermore, California 94550

8. PROJECT/TASK/WORK UNIT NUMBER

9. FIN OR GRANT NUMBER

A0448

10. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)

Division of Engineering and System Technology
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

11a. TYPE OF REPORT

Technical

11b. PERIOD COVERED (Inclusive dates)

October 1986-October 1988

12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

The EUS Seismic Hazard Characterization Project (SHC) is the outgrowth of an earlier study performed as part of the U.S. Nuclear Regulatory Commission's (NRC) Systematic Evaluation Program (SEP). The objectives of the SHC were: (1) to develop a seismic hazard characterization methodology for the region east of the Rocky Mountains (EUS), and (2) the application of the methodology to 69 site locations, some of them with several local soil conditions. The method developed uses expert opinions to obtain the input to the analyses. An important aspect of the elicitation of the expert opinion process was the holding of two feedback meetings with all the experts in order to finalize the methodology and the input data bases. The hazard estimates are reported in terms of peak ground acceleration (PGA) and 5% damping velocity response spectra (PSV).

A total of eight volumes make up this report which contains a thorough description of the methodology, the expert opinion's elicitation process, the input data base as well as a discussion, comparison and summary volume (Volume VI).

Consistent with previous analyses, this study finds that there are large uncertainties associated with the estimates of seismic hazard in the EUS, and it identifies the ground motion modeling as the prime contributor to those uncertainties.

The data bases and software are made available to the NRC and to the public uses through the National Energy Software Center (Argonne, Illinois).

14. DOCUMENT ANALYSIS - a. KEYWORDS/DESCRIPTORS

Seismic hazard, Eastern U.S., ground motion

15. AVAILABILITY STATEMENT

Unlimited

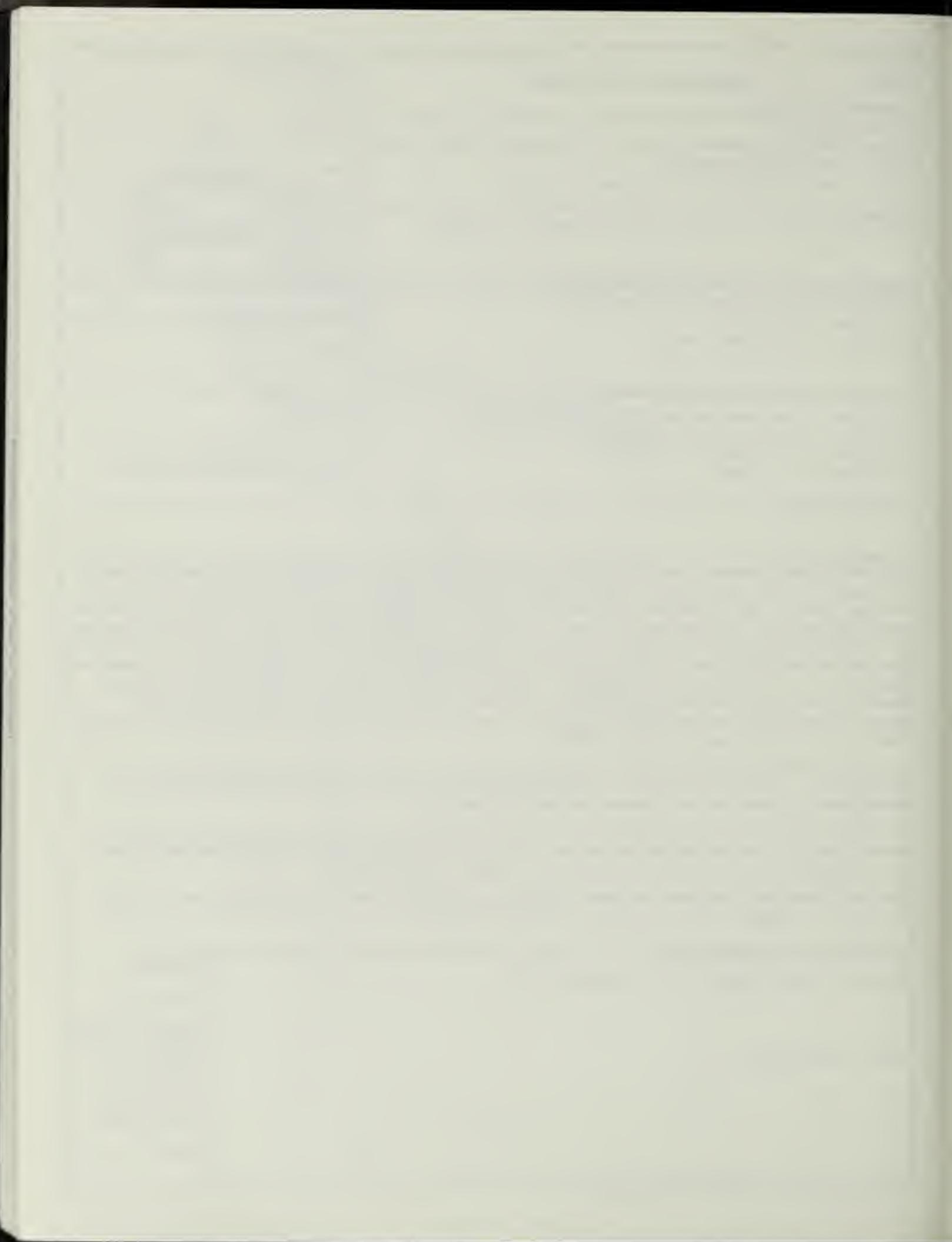
16. SECURITY CLASSIFICATION

17a. paper
Unclassified

17b. report
Unclassified

17. NUMBER OF PAGES

18. PRICE



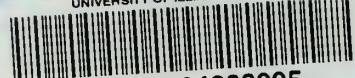


UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, \$300

SPECIAL FOURTH-CLASS RATE
POSTAGE & FEES PAID
USNRC
PERMIT No. G-67

UNIVERSITY OF ILLINOIS-URBANA



3 0112 084233995